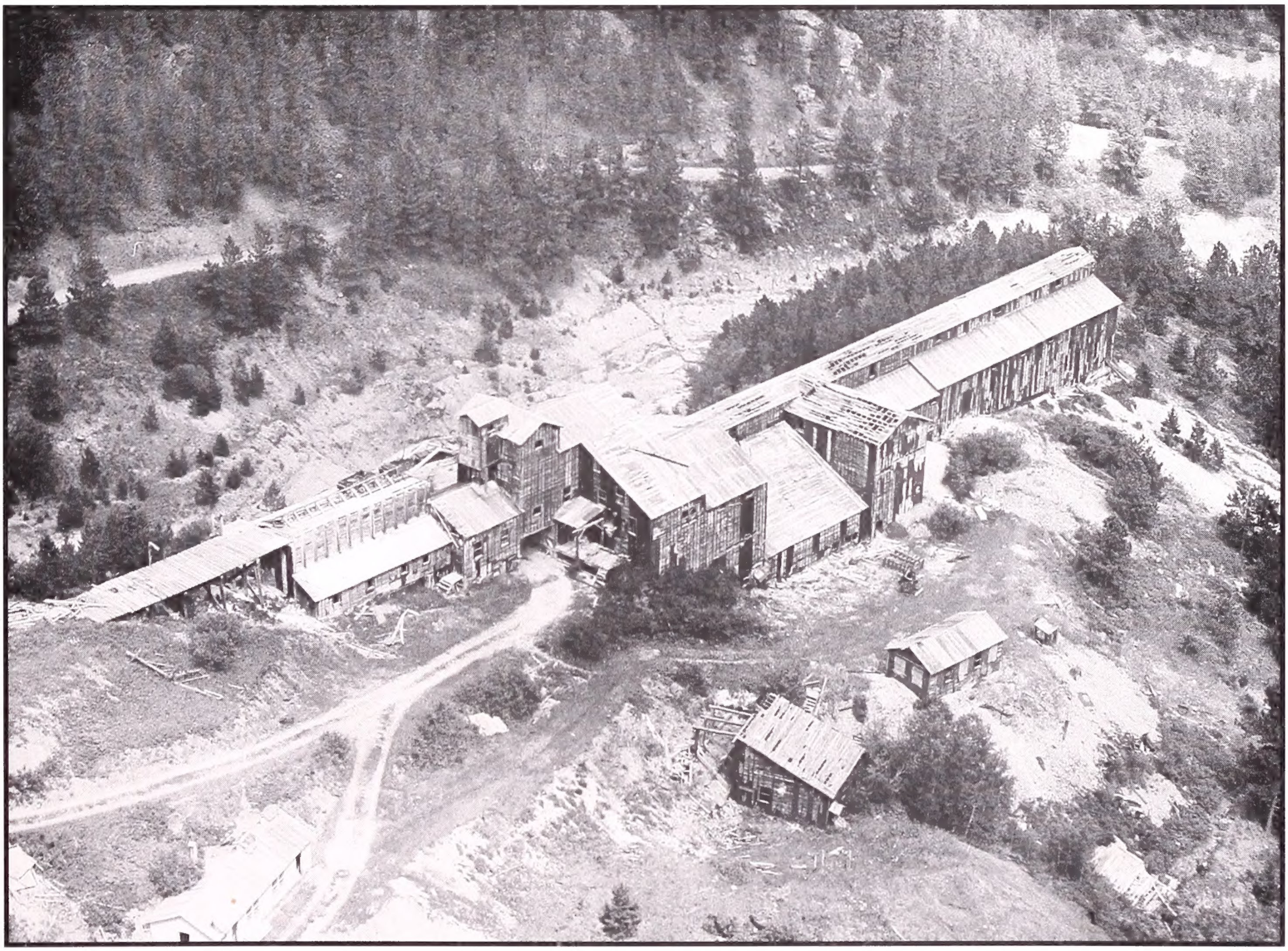
United States Department of the Interior
Bureau of Land Management
Lewistown District Office

State of Montana
Department of Environmental Quality
Hard Rock Bureau

March 1996

Volume I
Final Environmental Impact Statement
Zortman and Landusky Mines
Reclamation Plan Modifications and Mine Life Extensions



Historic Ruby Mill near the town of Zortman

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BLM/MT/PL-96/005+1990

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March 1996

Dear Reader:

Enclosed is the Final Environmental Impact Statement (EIS) for the expansion of the Zortman and Landusky mines in north central Montana, and modified reclamation plans at both mines. The Final EIS presents a preferred alternative (Alternative 7) and six other alternatives including the company proposed action. The Final EIS discloses the possible environmental consequences associated with each alternative.

About 400 copies of the Draft EIS were distributed to the public and other federal and state agencies in August 1995 for a 75-day comment period. During the public comment period the agencies held five open houses/public hearings to receive oral and written comments. In addition to oral comments, the agencies received 368 letters on the Draft EIS. All comments, written and oral, were reviewed and considered in preparation of the Final EIS. Comments that presented new data, questioned facts or analysis, or raised questions or issues bearing directly upon the alternatives or environmental analysis are responded to in this Final EIS. Comments expressing personal opinions or statements were considered but not responded to directly.

A number of changes have been made to the Preferred Alternative between the Draft EIS and Final EIS, largely in response to public comments. Major changes include: removal of the Peregrine Falcon reintroduction study for the pit highwalls, relocation of the limestone quarries to avoid impacts to northern drainages, routing of all post-reclamation pit runoff to the south, updating of the water quality improvement plan presented in Appendix A, completion of the Programmatic Agreement for mitigation of impacts to cultural resources presented in Appendix E, and the inclusion of new Appendix F which presents the aquatic ecosystem mitigation plans. Alternative 3 has also been changed to evaluate the agencies' preferred reclamation cover in combination with a non-mining alternative.

The agencies involved wish to thank all those who provided suggestions and comments on the Draft EIS. Additional copies of the Final EIS are available upon request from the Department of Environmental Quality or the Bureau of Land Management. A Record of Decision will be prepared no earlier than 30 days after the notice of receipt of the Final EIS is published in the Federal Register. A copy of the Record of Decision will be provided to everyone on the Final EIS mailing list.

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Final
Environmental Impact Statement

Zortman and Landusky Mines
Reclamation Plan Modifications and Mine Life Extensions
Phillips County, Montana

March 1996

Lead Agencies: United States Department of the Interior, Bureau of Land Management, Lewistown District and State of Montana, Department of Environmental Quality.

Cooperating Agencies: United States Environmental Protection Agency and United States Army Corps of Engineers.

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Abstract: This Final EIS analyzes impacts associated with expansion of mining and modification of reclamation plans at the Zortman and Landusky mines in north-central Montana. The Final EIS analyzes seven alternatives, including the No Action Alternative and the Company Proposed Action. Significant issues include: acid rock drainage, reclamation success, impacts to Native American traditional cultural and historic resources, and economics. A preferred alternative has been identified (Alternative 7) which addresses these, and other issues. This alternative would provide for expansion of mining and modified reclamation plans using mitigating measures developed by the lead agencies to avoid or reduce environmental impacts.

Other Environmental Review: This Final EIS will also serve as the environmental review document for a permit issued by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act.

Dates: A record of decision will be prepared no earlier than 30 days after the Notice of Receipt for the Final EIS is published in the Federal Register. A copy of the Record of Decision will be provided to everyone on the Final EIS mailing list.

INTRODUCTION

This Summary of the Final Environmental Impact Statement (EIS), prepared by the Montana Department of Environmental Quality (DEQ) and the U.S. Department of the Interior, Bureau of Land Management (BLM), describes the evaluation of a proposal by Zortman Mining, Inc. (ZMI) to continue and expand mining operations at both the Zortman and Landusky mines in Phillips County, Montana.

DEQ and BLM (referred to as "the agencies") are the joint lead agencies responsible for preparation of the Final EIS, and for issuing a final decision regarding the mine permit application. For purposes of impact evaluation, technical expertise was provided by an independent third-party consultant selected by, and working under the direction of, DEQ and BLM. The agencies will consider the proposed action and alternatives presented in this EIS and issue a decision on the permits and approvals required from the agencies for the Zortman and Landusky mine expansion projects. The final decisions and rationale will be presented in a document or documents known as the Record of Decision(s). More details concerning various lead and supporting agency responsibilities are presented in Chapter 1.0 of the Final EIS.

This summary of the Final EIS contains a description of the proposed action and other alternatives; identifies the agencies' preferred alternative; summarizes existing environmental conditions in the study area; and discloses the major impacts and issues associated with the various alternatives. If more detail is desired regarding all or certain aspects of these topics, the relevant sections of the Final EIS should be reviewed.

PROJECT DESCRIPTION, PURPOSE, AND NEED

Project Description

On May 11, 1992, ZMI filed an application with the Lewistown District BLM and the Montana DSL (part of the DEQ as of July 1, 1995) to expand mining operations at the Zortman Mine in the Little Rocky Mountains, Montana (See Figure ES-1). The proposal includes: expansion of existing mine pits to access sulfide ore; a 150-acre, 60-million ton waste rock disposal area; crushing facilities; a 2 ½-mile conveyor system; a 200-acre, 80-million ton leach pad; a new processing plant and ponds; a limestone quarry; and other associated facilities. Total disturbance would increase from the existing 401 acres to about 1,292 acres. The operation is located on private and BLM-managed land. Issues of special note include Native American religious concerns, acid rock drainage, reclamation, and socioeconomics. In a March 9, 1994, Decision Record, the BLM and DEQ included the analysis of acid rock drainage corrective measures for the nearby Landusky Mine within the scope of the EIS for the Zortman Mine expansion, since acid rock drainage has been a problem at both mines. The Final EIS addresses additional mining at the Landusky and Zortman mines, plus modified reclamation plans for both facilities.

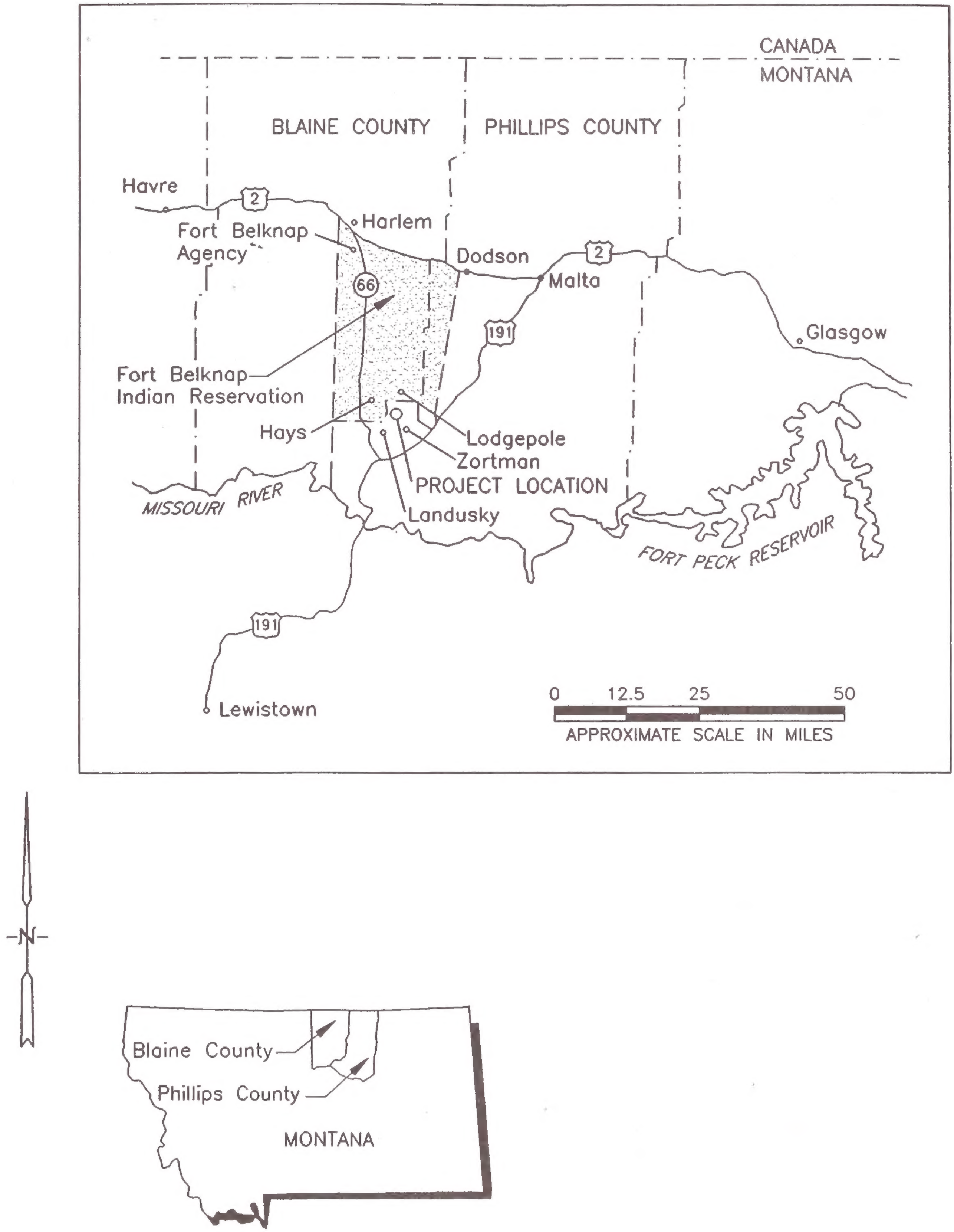
Purpose and Need

The purpose and need for these actions are to address two basic issues: (1) mineral development, and (2) environmental protection. In the first matter, the lands in the project area are either privates lands or public lands open to mineral development. ZMI has filed for approval of mineral development activity under relevant state and federal laws and regulations. ZMI's proposal for additional mining and reclamation is presented in Alternative 4.

Secondly, it has become apparent that existing operating and reclamation plans are not adequate to limit or prevent the development of acid rock drainage from the present mine facilities. In early 1993, the agencies informed ZMI that the reclamation plans had to be modified to mitigate existing acid rock drainage and to ensure successful surface reclamation. ZMI has submitted proposed modifications to the current reclamation plans. These are described under Alternatives 2 and 4.

There is some interdependence between mine expansion activities and corrective measures to address the inadequacies of the existing reclamation plans. To consider these in a comprehensive fashion, the scope of the EIS includes alternatives that address both these needs. However, while expansion of the mines and extension of the life of the two mines *is* dependent on proper reclamation and remediation, the reclamation and remediation actions are *not* dependent on further mining. In other words, adequate reclamation can be accomplished without further mining.

The EIS addresses impacts from past, present, and reasonably foreseeable future activities at the Zortman



SOURCE: DSL/BLM 1990.

LOCATION OF ZORTMAN
AND
LANDUSKY MINE EXPANSIONS

FIG. ES-1

MONTST

and Landusky mines. Baseline for this analysis is circa 1979 which marks the beginning of modern, large-scale mining in the Little Rocky Mountains. Earlier baseline is used when discussing specific historic mining disturbances such as the Ruby Gulch tailing.

The EIS Process

The environmental analysis of ZMI's applications for a mine permit modification for the Zortman and Landusky mines is being conducted under requirements of the National Environmental Policy Act (NEPA) and the Montana Environmental Policy Act (MEPA) and the administrative rules and regulations implementing both these acts. An EIS is required because the proposed permit modifications constitutes federal and state actions which may significantly affect the quality of the human environment under NEPA and MEPA. The BLM and the DEQ are the joint lead agencies responsible for the preparation of the EIS and for issuing a final decision on the mine permit applications. The U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (COE) are cooperating agencies, and several other agencies have provided comments.

The EIS process includes the following steps:

1. Public and agency "scoping" during which issues and concerns are identified early in the process;
2. Alternatives development;
3. Data collection;
4. Impact analysis;
5. Completion of a Draft EIS;
6. Public review and comment period;
7. Completion of a Final EIS, including responses to public comment, and
8. Completion of a Record of Decision (Final Decision)

At the end of the process, it is the responsibility of the BLM and DEQ as the lead agencies to consider the proposed action and alternatives presented in the EIS and issue a decision on the permit and approvals required for both the Zortman and Landusky Mine expansion projects. The BLM must review the Plan of Operations (the Proposed Action) to determine whether it would result in unnecessary or undue degradation of the federal lands. Measures needed to prevent unnecessary or undue degradation are incorporated into mitigated alternatives and would be required as conditions of approval. If it is determined that the action would not cause unnecessary or undue degradation, the BLM has to approve the Plan of Operations with any required conditions.

The final decisions and rationale will be presented in a document known as the Record of Decisions.

Major Issues

Significant areas of concern were identified through public scoping and agency project review. Public scoping meetings were held at various locations in the study area to solicit public comment. Based on scoping and agency review, four primary issues were identified that reflect concerns or conflicts which could be partially or totally resolved through the EIS process. These issues are:

- Water Quality
- Reclamation Plans and Procedures
- Native American Traditional Cultural Values
- Socioeconomics

These four issues are by no means the complete list of environmental concerns identified during project review and public scoping or used to develop alternatives. However, they do represent the issues that, because of the potential magnitude, duration, or significance of their effect on the environment, have played the greatest role in the development of alternatives. The following discussion provides a brief summary of these issues.

Water Quality. The public and the agencies have expressed concern that existing and/or historic mining operations have impacted and are continuing to impact water quality, and therefore aquatic habitat, in the area. Releases of acidic and metal-bearing waters from the mines have resulted in the loss of aquatic habitat and have adversely impacted the streams and groundwater in the area. Cyanide and metals are mentioned most often as analytes of concern.

Of particular interest is acid rock drainage and its effects on both surface and groundwater. Concern has been expressed that some of the existing mine, heap leach, and waste rock facilities have acidified and are releasing dissolved metals to ground and surface waters. The proposed mine expansion would develop sulfide ore and waste to an extent not contemplated previously for the Zortman and Landusky mines. Concerns have been raised regarding both mitigation of existing impacts and possible additional adverse water quality impacts from mine expansion.

Other water quality issues include the potential leakage of heap leach process solution from storage ponds, contamination of water in pits and release of that water to surface drainages and groundwater, and the scope and adequacy of the water quality monitoring program.

Substantial comment on the Draft EIS was directed toward the ongoing litigation to enforce compliance with the Montana Water Quality Act and the Federal Clean Water Act. Compliance with these acts is independent of the EIS process and a statutory requirement under any of the alternatives. The methods to achieve compliance may vary, though, and alternatives in this EIS reflect different approaches to achieving compliance.

<u>**Reclamation Plans and Procedures**</u>. Some reclamation at the mines has proved to be inadequate and/or ineffective. For instance, acid rock drainage emanating from some heap leach facilities and waste rock dumps may be due to incomplete reclamation procedures, or a failure to use appropriate materials to prevent water infiltration into the acid-producing materials. ZMI has proposed various rock characterization methods, materials handling procedures, and engineering practices to enhance the potential for successful reclamation. The agencies have also developed alternatives which incorporate engineering and reclamation modifications and mitigations as further protection. The scope and adequacy of reclamation monitoring has also been raised as an issue.

Pit backfilling is a significant reclamation issue raised during scoping and public review of the Draft EIS. The BLM and DEQ have evaluated variable amounts of pit backfilling, from complete pit backfill to reclaiming the pits in the existing configurations. The amount of pit backfilling in an alternative was determined by how well it addressed environmental issues such as the need to dispose of excess waste materials from other facilities or adjacent drainages; the need to promote runoff away from the pit areas; the need to cover potentially acid generating surfaces; and the need to mitigate visual or aesthetic impacts.

<u>**Native American Traditional Cultural Values**</u>. Areas within the Little Rocky Mountains, and specific sites near the Zortman and Landusky mines, are culturally and historically important to various North American Indian peoples. Many Native Americans regard the entire Little Rocky Mountains as sacred, and the range has been determined eligible for listing on the National Register of Historic Places as a Traditional Cultural Property. Many public comments have expressed concerns about impacts to cultural resources resulting from mine actions. The agencies have included an analysis of impacts to cultural resources and the use of these resources as a result of mine noise, air quality and water resources degradation, and modification of the visual perspective from certain locations of traditional cultural practices and importance.

A Programmatic Agreement under Section 106 of the National Historic Preservation Act has been developed that includes measures to mitigate impacts to the Traditional Cultural Property by preservation of historic and traditional associations through recordation. This mitigation has been incorporated as a part of each mine expansion alternative.

<u>**Socioeconomics**</u>. The Zortman and Landusky mines have employed a large number of workers during the years 1979 through 1995. This employment represents a significant percentage of the total workforce in Phillips County, although the mines have had little direct economic impact on Blaine County or the Fort Belknap Indian Reservation. A concern to many people, expressed during project scoping and public review of the Draft EIS, is the socioeconomic impact mine closure would have upon mine workers and the area economic base. The Zortman and Landusky mines have stopped mining, and workforce reductions have occurred. At the same time, comments received during scoping and on the Draft EIS also stress the social and environmental costs of past and continued mining.

PROPOSED ACTION AND ALTERNATIVES

<u>Development of Alternatives</u>

The issues identified through agency review and public scoping efforts were used to formulate reasonable alternative actions pertaining to the proposed Zortman and Landusky mine expansion. These alternatives were evaluated based on engineering, environmental, and economic factors. The engineering evaluation included technical implementability and effectiveness, while the environmental evaluation considered potential impacts on air, water, and soil, with consideration of subsequent impacts to cultural resources, vegetation, wildlife, and human health. Cost was only considered as a factor in the elimination of an alternative where it would likely result in an uneconomic mine project, thus equating to the No Action Alternative. The following describes in more detail the considerations evaluated by the agencies in developing project alternatives.

Several alternatives were developed regarding the location of two major facility components of the proposed action: 1) the waste rock storage facility site and 2) the location for the ore heap leaching facility. At the Zortman Mine, seven alternatives to the proposed Carter Gulch waste rock storage site were evaluated. Two of these - the Ruby Flats site, and partial backfill of the mine pits with placement of waste rock on top of and adjacent to existing disturbances - were retained as

viable waste rock storage alternatives for detailed evaluation in addition to the proposed Carter Gulch location. At the Landusky Mine, the proposed waste rock storage alternative (Gold Bug site or backfilling in other pits) was considered the only reasonable alternative. Regarding heap leach locations at the Zortman Mine, five alternatives to the proposed Goslin Flats location were considered, but only Alder Gulch remains as a viable alternative heap leach site for detailed evaluation. At the Landusky Mine, alternative sites for expansion of the existing pad were considered but eliminated.

In addition to the two major facility components discussed above, several items were considered for incorporation into an agency-modified alternative. These included:

- mining methods
- reclamation
- ore transport
- beneficiation technology
- conveyor route
- process solution storage
- leach pad type
- processing
- waste rock transport
- water control, and
- reclamation materials sources.

Alternative actions were then developed by considering and evaluating:

- Company proposed action;
- Agency comments to the company proposed action, generated during completeness reviews;
- Public comments about the proposed expansion projects, solicited during scoping;
- Experiences at other mining projects;
- Technical literature and the relevant scientific database; and
- Past and present environmental concerns at the Zortman and Landusky mines.

Following review of engineering, environmental, and economic feasibility, seven alternatives were retained for detailed analysis. These include the No Action Alternative, Company Proposed Reclamation, Company Proposed Expansions and Reclamation, and four other agency-mitigated alternatives. Actions which were eliminated from further evaluation were considered to be unacceptable in terms of engineering feasibility or environmental protection. Complete backfilling of the pits was eliminated from consideration because it would create an economically non-viable mining alternative.

Summary Description of Alternatives

The seven alternatives (including the proposed action) are listed and described below. For ease of reading, these are arranged from the simplest (No Action) to the most complex (Expanded Mining with Imposed Mitigation). The exhibits enclosed in the pocket at the back of this document illustrate the current and proposed permit areas, and various facilities and disturbances associated with alternative actions.

Alternative 1: No Action - Mine Expansions Not Approved and Existing Reclamation Plans

Alternative 2: Mine Expansions Not Approved and Company Proposed Reclamation

Alternative 3: Mine Expansions Not Approved and Mitigated Reclamation

Alternative 4: Company Proposed Expansions and Reclamation (Company Proposed Action or CPA)

Alternative 5: Mitigated Expansion and Reclamation with Leach Pad Located in Upper Alder Gulch rather than on Goslin Flats

Alternative 6: Mitigated Expansion and Reclamation with Waste Rock Repository Located on Ruby Flats rather than in Carter Gulch

Alternative 7: Mitigated Expansion and Reclamation with Waste Rock Repository Located on Existing Mine Facilities rather than in Carter Gulch

Alternative 1 - No Action - Mine Expansions Not Approved and Existing Reclamation Plans. At the **Zortman Mine,** mine expansion plans would not be approved. At the **Landusky Mine,** expansion plans would not be approved. ZMI has reached the extent of permitted ore reserves at the Landusky Mine and only ore which has already been mined is being processed. Leaching and reclamation would continue as permitted.

Alternative 2 - Mine Expansions Not Approved and Company Proposed Reclamation. ZMI would continue already permitted activities at both the Zortman and Landusky mines. Mine expansion plans would not be approved. The existing reclamation plans for the mines would be revised as proposed by ZMI to mitigate the existing acid rock drainage problems. Company

proposed revisions include low permeability capping of unreclaimed heaps and waste rock dumps, redesign of diversion structures, water treatment contingencies, and enhanced monitoring for evaluating reclamation effectiveness.

Zortman Mine - Existing mine facilities would be tested to determine their acid generation potential. Those facilities that could generate acid rock drainage would be reclaimed with a 6-inch compacted clay infiltration barrier between the mine waste unit and the topsoil. Clay material for reclamation would be mined from the Seaford clay pit approximately 9 miles south of Zortman.

Landusky Mine - The existing Landusky Mine disturbances would be reclaimed using enhanced reclamation measures proposed by ZMI. The existing interim reclamation covers on the Mill Gulch and Gold Bug waste rock repositories would become the final covers. The other mine waste units would be tested to determine their acid generation potential. Those facilities that could generate acid rock drainage would be reclaimed with a 6-inch compacted clay infiltration barrier between the mine waste unit and the topsoil. Clay material for reclamation would be mined from the Williams clay pit approximately 2 miles west of Landusky.

Alternative 3 - Mine Expansions Not Approved and Mitigated Reclamation. This is similar to Alternative 2 described above, but with additional agency-imposed requirements on ZMI's proposed plans to ensure reclamation success. Significant mitigations at both mines include:

- The use of water balance reclamation covers on slopes greater than or equal to 25 percent to limit surface water infiltration and provide a better medium for revegetation,
- The use of a Geosynthetic Clay Liner (GCL) on slopes less than 25 percent to provide a low permeability barrier that is resistant to desiccation by freezing and thawing or dehydration,
- Placement of improved reclamation covers on waste rock facilities and ore heaps,
- Reduction of most facilities to an overall slope of 3H:1V,
- Improvement and enhancement of capture, pumpback, and treatment facilities to handle runoff/seepage from a 6.33-inch, 24 hour storm event, and
- Implementation of a more restrictive geochemical classification system for materials used in construction and reclamation.

Other mitigating measures specific to the two mines are described below.

Zortman Mine - Development of a limestone quarry at the LS-2 site to be used for reclamation materials; removing the existing Alder Gulch waste rock dump and using it for mine pit backfilling; removing the OK waste rock dump and Ruby Gulch waste rock dump (sulfide stockpile) and placing them in the mine pit as backfill; removing the 85/86 leach pad and retaining dike and using it as mine pit backfill; backfilling of the mine pit to about 4,900 foot msl, and grading and capping of the mine pits floors to achieve a free-draining surface that discharges into Ruby Gulch; and removal of the Ruby Gulch tailing for use in reclamation covers and restoration of the Ruby Gulch drainage.

Landusky Mine - Development of a limestone quarry in the Montana Gulch area in the southwest portion of the permit boundary to be used for reclamation materials; backfilling of the pits to about 4,740 foot msl, grading and capping of the pit floor; excavation of a drainage notch to route surface runoff from the reclaimed pit floors into Montana Gulch; construction of a drainage channel along the west margin of the 85/86 leach pad to allow unimpeded drainage from the western tributary of Montana Gulch; and redistribution of spent ore from the 87/91 pad to eliminate the potential for surface water runoff to the north.

Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action or CPA). This is ZMI's proposed Zortman Mine Expansion Plan contained in the application documents initially submitted to BLM and DSL on May 11, 1992 and revised through the completeness process. It also includes the smaller proposed expansion of the Landusky Mine detailed in the ZMI document of September, 1994 as amended. Enhanced reclamation measures for both operations are included in the proposals. These are collectively known as the Company Proposed Action (CPA).

Zortman Mine - Approximately 879 additional acres would be disturbed. Major disturbances would be from construction of the leach pad, the waste rock repository, crusher, conveyor system, and processing facilities. Mining activities would expand and deepen the current

pit areas. The proposed limestone quarry, shale pit expansion, Goslin Flats leach pad, Landusky powerline extension, and the conveyor would be outside the current mine permit boundaries.

ZMI proposes to mine and process oxide and non-oxide ore reserves. The proposed expansion would include mining 80-million tons of ore and 60-million tons of waste rock at the rate of 60,000-80,000 tons per day, 350 days per year for 5 to 8 years. The operation would enlarge the existing pits, combine run-of-mine oxide and crushed non-oxide ore, and transport the ore via a 12,000-foot overland conveyor to a cyanide heap leach facility located at Goslin Flats. Cyanide solution would be applied to the ore heap and the precious metal-enriched solution would be captured within the leach pad, and processed at an adjacent recovery facility. Precious metals from the recovery process would be smelted to a dore' bullion product on site.

Support facilities for mining and processing would include existing offices, shops, labs, warehouse, and explosive storage facilities. A new land application disposal area would be on Goslin Flats adjacent to the leach pad. Electrical power would be delivered to the operation along existing powerline corridors owned and operated by Big Flat Electric. A buried powerline would be constructed between the Zortman and Landusky mines to use available power supply from the Landusky Mine.

One million tons of limestone is proposed to be mined from a quarry in upper Beaver Creek (LS-1) to support drainage construction and mine waste unit reclamation. Shale would be mined from the Seaford clay pit for leach pad liner and reclamation cap construction.

In addition to expanding operations at the Zortman Mine, ZMI also proposes to change the present reclamation plan for existing facilities. ZMI proposes to enhance surface reclamation of all existing leach pads, containment dikes, and waste rock dumps to restrict infiltration of precipitation into these facilities, thereby preventing or limiting acid rock drainage. All existing facilities would be resloped to 3H:1V where topography allows. Where testing indicates acid generating materials are present, the surface would be reclaimed by placement of two compacted 6-inch clay layers, overlain with 36-inches of non-acid generating rock, followed by 8-inches of topsoil with surface revegetation. Where surface slopes are less than 5 percent, a PVC liner with a geotextile would be placed immediately above the clay liner.

ZMI also proposes to remove the existing Alder Gulch waste rock dump (an acid rock drainage source) before the area is covered by the proposed Carter Gulch waste rock facility and transport it to Goslin Flats. Some of the spent ore from the 85/86 leach pad would be used to backfill the mine pits at the end of mining to achieve a free-draining pit floor configuration.

All seepage capture and pumpback systems would be sized to accommodate the seepage resulting from a 6-inch, 24-hour storm event. A water treatment plant with a 2,000 gpm capacity would be used to improve the quality of effluent from the mine facilities. Active water treatment would be phased out as source controls proved effective. Passive methods such as wetlands and limestone drains would be used in the long term.

Landusky Mine - There are no remaining permitted ore reserves at the Landusky Mine. ZMI has proposed mining an additional 7.6 million tons of ore and 7 million tons of waste rock, which would extend the mine life by less than one year. Four million tons of the waste rock would be scheduled as backfill in the Gold Bug waste rock facility. The remaining waste rock would be stored in the mine pits for use in reclamation.

The 7.6 million tons of additional ore is proposed to be placed on the existing 87/91 leach pad extension. The ore would be stacked on top of the existing ore increasing the heap height by 50 feet. This would require no increase in surface disturbance.

Besides additional mining, ZMI proposes to enhance the existing reclamation plans for the Landusky Mine to address acid rock drainage concerns. ZMI proposes to enhance surface reclamation of all unreclaimed leach pads, containment dikes, and waste rock piles to restrict infiltration of precipitation into these facilities thereby preventing or limiting acid rock drainage. All existing facilities would be resloped to 3H:1V where topography allows. Where testing indicates acid generating materials are present, the surface would be reclaimed by placement of two compacted 6-inch clay layers, overlain with 36-inches of non-acid generating rock, followed by 8-inches of topsoil with surface revegetation. Where surface slopes are less than 5 percent, a PVC liner with a geotextile would be placed immediately above the clay liner. The existing interim reclamation covers on the Mill Gulch and Gold Bug waste rock repositories would become the final reclamation covers.

The existing acid rock drainage seepage and pumpback systems in Mill Gulch and Rock Creek would be sized to accommodate runoff/seepage from a 6-inch, 24-hour storm event. A water treatment plant with a 2,000 gpm

capacity would be constructed in the Montana Gulch area to improve the quality of effluent from the mine facilities if the need arises. Active water treatment would be phased out as source controls took effect. Passive methods such as wetlands and limestone drains could be used in the long term.

ZMI would mine approximately 50,000 tons of limestone from a 10-acre quarry to be developed on private land in the King Creek area. This material would be used to construct drains and diversions to aid in reclamation and maintenance of water quality.

Alternative 5 - Mitigated Expansion and Reclamation with Leach Pad Located in Upper Alder Gulch rather than on Goslin Flats. This alternative is similar to the CPA (Alternative 4) for both mine expansion and modification of reclamation plans, but with agency mitigation added to reduce or avoid potential environmental impacts. Significant mitigations at both mines include:

- Modification of the reclamation covers described in Alternative 4,
- Improvement and enhancement of capture, pumpback, and treatment facilities to handle runoff/seepage from a 6.33-inch, 24 hour storm event, and
- Implementation of a more restrictive geochemical classification system for materials used in construction and reclamation.

Other mitigating measures to be implemented at the two mines are described below.

Zortman Mine - The major change is that the Goslin Flats leach pad would be constructed in Upper Alder Gulch just west of the proposed waste rock dump. The conveyor system would not be constructed. Trucks would transport both ore and waste rock from the mine to their respective facilities.

The agencies would also require changes in ZMI's proposed reclamation plans to improve the potential for reclamation success.

Landusky Mine - No change would occur in mining operations from that proposed in Alternative 4.

Modification to the reclamation plans would be similar to Alternative 3, except that the post-reclamation pit drainage would include cutting a drainage channel or notch out of the pit wall so that all surface water runoff from the pit floor would drain into King Creek. Contingency water capture systems and settling ponds would be installed in King Creek. A drainage diversion would be constructed along the pit highwall so that highwall runoff would discharge into Montana Gulch. The mine pit would be backfilled to an elevation of approximately 4,850 feet msl or the minimum elevation necessary for free drainage to King Creek.

Alternative 6 - Mitigated Expansion and Reclamation with Waste Rock Repository Located on Ruby Flats rather than in Carter Gulch. This alternative is the same as the Company Proposed Action for both mine expansion and modification of reclamation plans, but with agency mitigation added to reduce or avoid potential environmental impacts. Significant mitigations at both mines include:

- Modification of the reclamation covers described in Alternative 4,
- Improvement and enhancement of capture, pumpback, and treatment facilities to handle runoff/seepage from a 6.33-inch, 24 hour storm event, and
- Implementation of a more restrictive geochemical classification system for materials used in construction and reclamation.

Other mitigating measures to be implemented at the two mines are described below.

Zortman Mine - The major modification is that the Alder Gulch waste rock repository would not be constructed. Instead, waste rock would be disposed at a repository site on Ruby Flats east of the proposed leach pad. The waste rock would be transported from the mine site by the conveyor to an off-load area near the leach pad. It would then be transported by truck to Ruby Flats waste rock repository for disposal. This waste rock facility would be reclaimed similar to the leach pad. To facilitate this action the county-owned Seven Mile Road that connects the town of Zortman with U.S. Highway 191 would have to be re-routed around the waste rock repository.

The agencies would also require changes in ZMI's proposed reclamation plans to improve the potential for reclamation success. These mitigation measures would be similar to those in Alternative 3.

Landusky Mine - No change would occur in mining operations from that proposed in Alternative 4.

Modification to the reclamation plan would be similar to those in Alternative 3. The post-reclamation pit drainage would involve cutting a drainage notch or channel out of the pit wall so that all surface water runoff from the pit floor would drain into Montana Gulch. Spent ore from the 85/86 leach pad and dike would be excavated from Montana Gulch and used to backfill the mine pits. This would raise the backfilled pit floor elevation, thus decreasing the size of the drainage notch needed to achieve a free-draining surface, and it would remove potentially acid generating material from close proximity with the Montana Gulch drainage.

Alternative 7 (Preferred Alternative) - Mitigated Expansion and Reclamation with Waste Rock Repository Located on Existing Mine Facilities rather than in Carter Gulch. This alternative is similar to the Company Proposed Action for both mine expansion and modification of reclamation plans, but with agency mitigation added to reduce or avoid potential environmental impacts. Significant mitigations at both mines include:

- The use of water balance reclamation covers on slopes greater than or equal to 25 percent to limit surface water infiltration and provide a better medium for revegetation,
- The use of a Geosynthetic Clay Liner (GCL) on slopes less than 25 percent to provide a low permeability barrier that is resistant to desiccation by freezing and thawing or dehydration,
- Placement of improved reclamation covers on waste rock facilities and ore heaps,
- Improvement and enhancement of capture, pumpback, and treatment facilities to handle runoff/seepage from a 6.33-inch, 24 hour storm event, and
- Implementation of a more restrictive geochemical classification system for materials used in construction and reclamation.

Other mitigating measures at the two mines are described below.

Zortman Mine - The major modification is that the company proposed Carter Gulch waste rock repository would not be constructed. Instead, waste rock would be disposed on top of and adjacent to existing disturbances at the Zortman Mine. This would mean placement of waste rock over some of the existing leach pads and retaining dikes. The waste rock repository would be constructed at a 3H:1V slope and concurrently reclaimed as it was built upward from the lower slopes. The Alder Gulch and OK waste rock dumps would be removed and leached on the new leach pad at Goslin Flats to remove precious metals, or used as pit backfill.

Additional mitigations identified in the Alternative 3 description would apply. These include: Development of a limestone quarry at the LS-2 site to be used for reclamation materials (instead of the site in upper Lodgepole Creek); removing the existing Alder Gulch waste rock dump and using it for mine pit backfilling; removing the OK waste rock dump and Ruby Gulch waste rock dump (sulfide stockpile) and placing them in the mine pit as backfill; backfilling of the mine pit to about 4,800 foot msl, and grading and capping of the mine pits floors to achieve a free-draining surface that discharges into Ruby Gulch; and removal of the Ruby Gulch tailing for use in reclamation covers and restoration of the Ruby Gulch drainage.

The agencies would also require other changes in ZMI's proposed plans to ensure reclamation success and mitigate impacts from mine expansions.

Landusky Mine - No change would occur in mining operations from that proposed in Alternative 4.

Modification to the reclamation plan would be similar to those in Alternative 3 with slope reduction and improved reclamation covers. The post-reclamation pit drainage would involve cutting a drainage notch or channel out of the pit wall so that all surface water runoff from the pit floor would drain into Montana Gulch. The final pit floor elevation at the outlet to Montana Gulch would be at approximately 4,740 feet msl.

Comparison of Alternative Components. Tables ES-1 and ES-2 are provided to facilitate a comparison of the seven alternatives described above. The tables compare the differences in the various project components (type, location, extent, method, etc.) among the seven alternatives. A comparison of impacts among alternatives is provided later in the summary.

Summary of Agency Mitigations

During the development and evaluation of project alternatives, the agencies identified a number of mitigations designed to eliminate or substantively reduce environmental impacts. Many of these mitigations are integral parts of one or more alternatives. The only mitigation which applies to Alternative 1 is implementation of the Water Quality Improvement Plan. This mitigation applies to all alternatives. No specific

TABLE ES-1
SUMMARY OF ALTERNATIVES - ZORTMAN MINE

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion and Reclamation with Leach Pad in Upper Alder Gulch	Alternative 6 - Mitigated Expansion and Reclamation with Waste Rock Facility on Ruby Flats	Alternative 7 - Mitigated Expansion and Reclamation with Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Mine							
Location	97 acres in 6 pits - Ross Pit - South Alabama Pit - North Alabama Pit - OK Pit - Ruby Pit - Mint Pit	97 acres in 6 pits - Ross Pit - South Alabama Pit - North Alabama Pit - OK Pit - Ruby Pit - Mint Pit	97 acres in 6 pits - Ross Pit - South Alabama Pit - North Alabama Pit - OK Pit - Ruby Pit - Mint Pit	Vertical and lateral expansion of mine pit complex; 103 additional acres	Company Proposed Action	Company Proposed Action	Company Proposed Action
Extraction	No additional mining	No additional mining	No additional mining	Open pit, drill, blast, load - 80 million tons ore - 60 million tons waste rock	Company Proposed Action	Company Proposed Action	Company Proposed Action
Ore Transport	Not applicable	Not applicable	Not applicable	Truck to primary crusher and conveyor to leach pad	Truck haul	Company Proposed Action	Company Proposed Action
Waste Rock Transport	Not applicable	Not applicable	Not applicable	Truck haul to Carter Gulch repository	Company Proposed Action	Conveyor to Goslin Flats and truck haul to Ruby Flats	Stage at mine site, backfill, cover facilities
Ore Prep, Handling, and Storage							
Location	None	None	None	Primary crush below truck shop near 84 leach pad; secondary & tertiary crushing at Goslin Flats	All ore crushing near mine site	Company Proposed Action	Company Proposed Action
Crushing	None	None	None	Crush oxide and unoxidized	Company Proposed Action	Company Proposed Action	Company Proposed Action
Stockpile	None	None	None	Separate piles at head of conveyor	At mine site or near Upper Alder leach pad; separate at truck load-out	Company Proposed Action	Company Proposed Action
Conditioning	None	None	None	Blend unoxidized ore with oxide ore	Company Proposed Action	Company Proposed Action	Company Proposed Action

TABLE ES-1 - SUMMARY OF ALTERNATIVES - ZORTMAN MINE (Continued)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion and Reclamation with Leach Pad in Upper Alder Gulch	Alternative 6 - Mitigated Expansion and Reclamation with Waste Rock Facility on Ruby Flats	Alternative 7 - Mitigated Expansion and Reclamation with Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Ore Transport							
Location	Not applicable	Not applicable	Not applicable	Alder Gulch route to Goslin Flats, 2.5 acre conveyor corridor	New truck haul route (Antoine Butte) to Upper Alder leach pad	Company Proposed Action	Company Proposed Action
Method	Not applicable	Not applicable	Not applicable	Overland conveyor to Goslin Flats heap leach pad	Haul trucks	Company Proposed Action	Company Proposed Action
Beneficiation (Heap Leaching)							
Location	116 current acres at 7 existing heap leach sites - 79 pad (inactive) - 80/81 pad (inactive) - 82 pad (inactive) - 83 pad (inactive) - 84 pad (inactive) - 85/86 pad (inactive) - 89 pad (active)	116 current acres at 7 existing heap leach sites - 79 pad (inactive) - 80/81 pad (inactive) - 82 pad (inactive) - 83 pad (inactive) - 84 pad (inactive) - 85/86 pad (inactive) - 89 pad (active)	116 current acres at 7 existing heap leach sites - 79 pad (inactive) - 80/81 pad (inactive) - 82 pad (inactive) - 83 pad (inactive) - 84 pad (inactive) - 85/86 pad (inactive) - 89 pad (active)	Goslin Flats heap leach 205 acres	Upper Alder Gulch, heap leach, 180 acres	Company Proposed Action	Company Proposed Action
Method	Valley leach	Valley leach	Valley leach	Modified flat pad	Valley leach	Company Proposed Action	Company Proposed Action
Process Solution Storage							
Location	Existing facilities	Existing facilities	Existing facilities	Goslin Flats	Upper Alder Gulch	Company Proposed Action	Company Proposed Action
Method	In heap and external lined ponds	In heap and external lined ponds	In heap and external lined ponds	In heap and external lined ponds	In heap and external lined ponds	In heap and external lined ponds	In heap and external lined ponds

TABLE ES-1 - SUMMARY OF ALTERNATIVES - ZORTMAN MINE
(Continued)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion and Reclamation with Leach Pad in Upper Alder Gulch	Alternative 6 - Mitigated Expansion and Reclamation with Waste Rock Facility on Ruby Flats	Alternative 7 - Mitigated Expansion and Reclamation with Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Processing							
Location	Existing process plant, 8.5 acres, 1 site	Existing process plant, 8.5 acres, 1 site	Existing process plant, 8.5 acres, 1 site	Goslin Flats, 23 acres	Existing process plant	Company Proposed Action	Company Proposed Action
Method	Existing Facilities	Existing Facilities	Existing Facilities	Cyanide solution, carbon adsorption, electrowinning, smelting	Company Proposed Action	Company Proposed Action	Company Proposed Action
Mine Waste Disposal							
Waste Rock	25 acres in 3 Dumps - Alder Gulch (3,365,000 tons) - Ruby Gulch (850,000 tons) - OK Dump (1,235,000 tons)	25 Acres in 3 Dumps - Alder Gulch (3,365,000 tons) - Ruby Gulch (850,000 tons) - OK Dump (1,235,000 tons)	Alder Gulch, OK and Ruby Dumps backfilled into pit	New repository in Carter Gulch of Alder Gulch, 162 additional acres; truck haul, bottom-up construction. Alder Dump processed for ore	Company Proposed Action; OK and Ruby Dumps backfilled into pit; Alder Dump processed for ore	New repository on Ruby Flats; conveyor transport and truck haul, bottom-up construction lined impoundment; OK and Ruby Dumps backfilled into pit; Alder Dump processed for ore	New repository constructed over existing mine facilities; OK and Ruby Dumps backfilled into pit; Alder Dump processed for ore
Spent Heap Leach Ore or Tailings	Reclaim in place	Reclaim in place	85/86 leach pad/dike removed for pit backfill; Ruby Gulch tailing removed for use in reclamation; Other facilities reclaimed in place	Reclaim facilities in place; portion of 85/86 pad leached on Goslin Flats leach pad	85/86 leach pad & dike removed for pit backfill; Ruby Gulch tailing used in reclamation or construction; Other facilities reclaimed in place	85/86 leach pad & dike removed for pit backfill; Ruby Gulch tailing used in reclamation or construction; Other facilities reclaimed in place	Ruby Gulch tailing used in reclamation or construction; Other facilities reclaimed in place
Other Solid Waste	Lab wastes to ASARCO smelter, empty cyanide barrels crushed and buried in heap, sludge from water treatment plant to 89 leach pad	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

TABLE ES-1 - SUMMARY OF ALTERNATIVES - ZORTMAN MINE
(Concluded)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion and Reclamation with Leach Pad in Upper Alder Gulch	Alternative 6 - Mitigated Expansion and Reclamation with Waste Rock Facility on Ruby Flats	Alternative 7 - Mitigated Expansion and Reclamation with Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Other Facilities							
Access Roads	24 acres existing	24 acres existing	24 acres existing	23 additional acres of access road disturbance	Company Proposed Action	Company Proposed Action	Company Proposed Action
Limestone Quarry	None	None	LS-2 site, northwest of Zortman, in permit boundary	13 acres disturbance, LS-1 site, south of Green Mountain	Company Proposed Action	Company Proposed Action	LS-2 site, northwest of Zortman in permit boundary
Clay Pit (borrow)	Seaford Clay Pit, 4.2 acres existing, no additional disturbance	Seaford Clay Pit, 4.2 acres existing, 3.0 acres additional disturbance	Seaford Clay Pit, 4.2 acres existing, no additional disturbance	Seaford Clay Pit, 4.2 acres existing, 10 acres additional disturbance	Seaford Clay Pit, 4.2 acres existing, 11.5 acres additional disturbance	Seaford Clay Pit, 4.2 acres existing, 12 acres additional disturbance	Seaford Clay Pit, 4.2 acres existing, additional disturbance for leach pad construction
Top Soil Stockpile	Various locations, 15.5 acres	Various locations, 15.5 acres	Existing stockpiles and Goslin Flats	Goslin Flats, 48 additional acres	Alder Gulch	Company Proposed Action and Ruby Flats	Company Proposed Action
Power Corridor	Existing Facilities	Existing Facilities	Existing Facilities	Buried construction, 9 additional acres	Company Proposed Action	Company Proposed Action	Company Proposed Action
Solution Pipeline	Existing Facilities	Existing Facilities	Existing Facilities	10" pipeline along conveyor route	Existing Facilities	Company Proposed Action	Company Proposed Action
Reclamation							
Mine Pits	Existing permit requirements	Existing permit requirements	Partial backfill pit and Enhanced Reclamation	Partial backfill pit to drain by gravity, revegetate, divert surface water inflows, cover and revegetate benches and pit floor	Enhanced Company Proposed Action Reclamation with additional backfill	Enhanced Company Proposed Action Reclamation with additional backfill	Enhanced Company Proposed Action Reclamation with additional backfill
Waste Rock Dumps and Repositories	Existing permit requirements	Existing permit requirements, cap modifications	Water balance and barrier covers, Alder Gulch and OK dumps used as pit backfill	Concurrent reclamation, capping, revegetation, waste segregation/ encapsulation, Covers A, B or C	Enhanced Company Proposed Action Reclamation, Covers B or Modified C, with OK dump used as pit backfill	Enhanced Company Proposed Action Reclamation, Covers B or Modified C with OK dump used as pit backfill	Enhanced reclamation water balance and water barrier covers
Leach Pads	Existing permit requirements	Existing permit requirements, geochemical testing, Reclamation Cover A	Water balance and barrier covers on heap leach pads, Company Proposed Action with minor modifications	Neutralize in-place with fresh water rinses, perforate liner, capping, revegetation	Enhanced Company Proposed Action Reclamation, Covers B or Modified C on heap leach pads	Enhanced Company Proposed Action Reclamation, covers B or Modified C on heap leach pads	Enhanced reclamation water balance and water barrier covers

TABLE ES-2
SUMMARY OF ALTERNATIVES - LANDUSKY MINE

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion (Zortman Mine Leach Pad in Upper Alder Gulch) and Reclamation	Alternative 6 - Mitigated Expansion (Zortman Mine Waste Rock Facility at Ruby Flats) and Reclamation	Alternative 7 - Mitigated Expansion and Reclamation with Zortman Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
<u>Mine</u>							
Location	Existing disturbance of 235 Acres in 5 Pits - Queen Rose Pit - August Pit - Little Ben Pit - Gold Bug Pit - Niseka Pit	Same as Alternative 1	Same as Alternative 1	Vertical expansion of existing South Gold Bug pit	Company Proposed Action	Company Proposed Action	Company Proposed Action
Extraction	Open pit, drill, blast, load; permitted disturbance	Same as Alternative 1	Same as Alternative 1	Open pit, drill, blast, load; additional 7.6 million tons ore & 7.0 million tons waste rock	Company Proposed Action	Company Proposed Action	Company Proposed Action
Ore Transport	Truck to 87/91 heap leach pad	Same as Alternative 1	Same as Alternative 1	Truck to expanded 87/91 heap leach pad	Company Proposed Action	Company Proposed Action	Company Proposed Action
Waste Rock Transport	Truck to Gold Bug waste rock repository	Same as Alternative 1	Same as Alternative 1	Truck to expanded Gold Bug waste rock repository	Company Proposed Action	Company Proposed Action	Company Proposed Action
<u>Ore, Prep, Handling, and Storage</u>	All ore run of mine; no stockpiles, crushing, or conditioning	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
<u>Ore Transport</u>							
Location	Existing Roads	Existing Roads	Existing Roads	Existing Roads	Existing Roads	Existing Roads	Existing Roads
Method	Truck Haul	Truck Haul	Truck Haul	Truck Haul	Truck Haul	Truck Haul	Truck Haul

TABLE ES-2 - SUMMARY OF ALTERNATIVES - LANDUSKY MINE (Continued)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion (Zortman Mine Leach Pad in Upper Alder Gulch) and Reclamation	Alternative 6 - Mitigated Expansion (Zortman Mine Waste Rock Facility at Ruby Flats) and Reclamation	Alternative 7 - Mitigated Expansion and Reclamation with Zortman Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
<u>Beneficiation (Heap Leaching)</u>							
Location	280 Current Acres at 8 Existing Heap Leach Sites - 79 pad (inactive) - 80/81/82 pad (inactive) - 83 pad (inactive) - 84 pad (inactive) - 85/86 pad (leaching) - 87 pad (leaching) - 91 pad (loading & leaching) - 87/91 pad (loading & leaching)	Same as Alternative 1	Same as Alternative 1	87/91 pad expansion	Company Proposed Action	Company Proposed Action	Company Proposed Action
Method	Valley Leach	Valley Leach	Valley Leach	Valley Leach	Valley Leach	Valley Leach	Valley Leach
<u>Process Solution Storage</u>							
Location	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities
Method	In Heap and External Lined Pond	In Heap and External Lined Pond	In Heap and External Lined Pond	In Heap and External Lined Pond	In Heap and External Lined Pond	In Heap and External Lined Pond	In Heap and External Lined Pond
<u>Processing</u>							
Location	2 sites - 87 pad - Landusky Plant	2 sites	2 sites	2 sites	2 sites	2 sites	2 sites
Method	Existing facilities, Merrill-Crowe and Carbon Adsorption	Same as Alternative 1	Same as Alternative 1	Same processes as currently used; Merrill-Crowe and Carbon Adsorption	Company Proposed Action	Company Proposed Action	Company Proposed Action

TABLE ES-2 - SUMMARY OF ALTERNATIVES - LANDUSKY MINE (Continued)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion (Zortman Mine Leach Pad in Upper Alder Gulch) and Reclamation	Alternative 6 - Mitigated Expansion (Zortman Mine Waste Rock Facility at Ruby Flats) and Reclamation	Alternative 7 - Mitigated Expansion and Reclamation with Zortman Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Mine Waste Disposal							
Waste Rock	171 acres existing disturbance, 184 acres permitted, in 3 facilities - Montana Gulch (8,000,000 tons) - Mill Gulch (17,000,000 tons) - Gold Bug Repository Plus Heap Leach Pad Embankments (14,000,000 tons)	Same as Alternative 1	Same as Alternative 1	Expand Gold Bug Repository; 7.0 million tons generated during expansion used as pit backfill	Company Proposed Action with additional backfill	Company Proposed Action with additional backfill	Company Proposed Action with additional backfill
Spent Heap Leach Ore	Reclaim in place	Reclaim in place	Reclaim in place, water balance and water barrier covers	Reclaim in place, Company Proposed Action barrier reclamation covers	Reclaim in place enhanced barrier reclamation covers	Reclaim in place enhanced barrier reclamation covers	Reclaim in place water balance and water barrier reclamation covers
Other Solid Waste	Lab wastes to ASARCO smelter, empty cyanide barrels crushed, buried in heap, municipal waste to County landfill	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Other Facilities							
Limestone Quarry	King Creek quarry, 3 acres existing disturbance, no additional disturbance	King Creek quarry, 3 acres existing disturbance, no additional disturbance	Montana Gulch Quarry, 3 acres disturbance	King Creek quarry, 3 acres existing disturbance, 3 acres additional disturbance	King Creek quarry, 3 acres existing disturbance, 3 acres additional disturbance	King Creek quarry, 3 acres existing disturbance, 3 acres additional disturbance	Montana Gulch Quarry, 2 acres disturbance
Clay Pit (borrow)	Williams Pit, 26 acres existing disturbance, no additional disturbance	Williams Pit, 26 acres existing disturbance, 6 acres additional disturbance	No acres additional disturbance	Williams Pit, 26 acres existing disturbance, 7 acres additional disturbance	Williams Pit, 26 acres existing disturbance, 9 acres additional disturbance	Williams Pit, 26 acres existing disturbance, 9 acres additional disturbance	Williams Pit, 26 acres existing disturbance, no additional disturbance

TABLE ES-2 - SUMMARY OF ALTERNATIVES - LANDUSKY MINE (Concluded)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion (Zortman Mine Leach Pad in Upper Alder Gulch) and Reclamation	Alternative 6 - Mitigated Expansion (Zortman Mine Waste Rock Facility at Ruby Flats) and Reclamation	Alternative 7 - Mitigated Expansion and Reclamation with Zortman Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
<u>Other Facilities, Continued</u>							
Top Soil Stockpile	Various Locations	Various Locations	Various Locations	Various Locations	Various Locations	Various Locations	Various Locations
Power Corridor	Existing Facilities	Existing Facilities	Existing Facilities	Buried construction, 9 additional acres, line connecting to Zortman Mine	Company Proposed Action	Company Proposed Action	Company Proposed Action
Solution Pipeline	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities
<u>Reclamation</u>							
Mine Pits	Existing permit requirements	Existing permit requirements	Partial backfill pit, water balance and barrier reclamation covers, drainage notch to direct surface water to Montana Gulch	Partial backfill pit to drain by gravity, revegetate, divert surface water inflows, cover and revegetate benches and pit floor; surface water to August drain tunnel	Partial backfill pit, enhanced reclamation covers, direct surface water to King Creek	Partial backfill pit, enhanced reclamation covers, drainage notch to direct surface water to Montana Gulch	Partial backfill pit, water balance and barrier covers, divert surface water and highwall runoff to Montana Gulch
Waste Rock Dumps and Repositories	Existing permit requirements	Existing permit requirements, geochemical testing, Reclamation Cover A	Enhanced reclamation water balance and water barrier covers	Concurrent reclamation, capping, revegetation, waste segregation/encapsulation	Enhanced Company Proposed Action Reclamation, Covers B or Modified C on waste rock facilities	Enhanced Company Proposed Action Reclamation, Covers B or Modified C on waste rock facilities	Enhanced reclamation water balance and water barrier covers
Leach Pads	Existing permit requirements	Existing permit requirements, geochemical testing, Reclamation Cover A	Enhanced reclamation water balance and water barrier covers	Neutralize in-place with fresh water rinses, perforate liner, capping, revegetation	Enhanced Company Proposed Action Reclamation, Covers B or Modified C on heap leach pads	Enhanced Company Proposed Action Reclamation, Covers B or Modified C on heap leach pads	Enhanced reclamation water balance and water barrier covers

mitigations have been developed for Alternatives 2 or 4 since they were proposed by ZMI.

The following is a list of mitigations which have been incorporated into one or more agency-mitigated alternatives (Alternatives 3, 5, 6 and 7). The numbers in parentheses following each mitigation refer to the alternatives containing the mitigation, although each alternative should be read and considered for the context in which a particular mitigation is applied.

Mitigations Common to Both Mines

- Mine activities would be conducted in accordance with the Water Quality Improvement Plan described in Appendix A. (all alternatives)

- All mine expansion and reclamation activities would be conducted in accordance with the signed Programmatic Agreement developed under Section 106 of the National Historic Preservation Act (see Appendix E). (4, 5, 6, 7)

- ZMI's proposed Reclamation Cover C would be modified to include 6 inches of compacted clay (as opposed to 3 inches of compacted clay) between the bottom substrate and the PVC liner. The PVC liner thickness would be increased to 30 mil. For the purpose of discussion in this and future alternatives, this cover is known as "Modified Reclamation Cover C." (5, 6)

- To limit surface water infiltration and provide a better media for revegetation, water balance and water barrier reclamation covers would be used on most facilities and disturbances. (3, 7)

- Unless specifically identified below, mine waste rock facilities and ore heaps are assumed to be acid generating and would have improved reclamation covers installed. Cover soil on the facilities would be removed, stockpiled, and reused. (3, 5, 6, 7)

- To reduce erosion and soil loss, increase overall surface reclamation success, and increase stability most facilities would be reclaimed to an overall 3H:1V slope with constructed benches every 100 vertical feet between benches. In order to achieve the slope reductions while minimizing additional land disturbance some material may have to be off-loaded from existing facilities and used as pit backfill. (3, 5, 6, 7)

- To enhance the probability of long-term reclamation success, soil loss from reclaimed areas must be less than 2 tons/acre/year. (3, 5, 6, 7)

- To avoid impacts in northern drainages the limestone quarries would be sited within existing mine permit boundaries, at the Montana Gulch site for the Landusky Mine and LS-2 site for the Zortman Mine. (3, 7)

- In order to classify as "Non-Acid Generating" (NAG) and be used without restriction in construction and reclamation, waste rock (3, 5, 6, 7):

  1. Cannot be composed of breccia, felsic gneiss, monzonite, quartzite, or trachyte lithologies;

  2. If amphibolite, mafic gneiss, shale, dolomite, or limestone must have a total sulfur content less than or equal to 0.8 percent, and a Paste pH of 6.0 or greater;

  3. If syenite, must have a total sulfur content less than or equal to 0.2 percent, a Paste pH of 6.5 or greater, and a Net Neutralization Potential (NNP) of 0 or greater;

  4. Must meet the criteria above as demonstrated by sampling and analyzing lithologies from every blasthole providing non-acid generating material for total sulfur, Paste pH and Neutralizing Potential. All blastholes within a discrete mineable block (25 feet x 25 feet) must meet these criteria.

  5. If syenite, can only be used in reclamation covers and not for fill or other construction.

- To ensure that only non-acid generating materials are used in facilities transporting surface water or seepage water, material used as capillary break/drainage layers may be obtained from the unmineralized sources specified in the text. (3, 5, 6, 7)

- Rock underdrains would be built with durable, unmineralized limestone, as an additional precaution to buffer acidic drainage. (3, 5, 6, 7)

- No trees would be used in revegetation except on a limited basis for visual impact mitigation. Grasses, forbs and shrubs would be used to enhance wildlife habitat. In addition, crested wheatgrass could not be used in the reclamation seed mix. (3, 5, 6, 7)

- Vegetative cover must achieve 90 percent of that demonstrated in adjacent, natural communities of similar composition and location to be considered acceptable. (3, 5, 6, 7)

- An expanded monitoring program would be implemented and reclamation viability would be monitored by ZMI until the agencies have approved final closure and released the mine reclamation bond. (3, 5, 6, 7)

- A number of new monitoring wells and surface water monitoring stations would be installed north and south of the two mines. (3, 5, 6, 7)

- Prior to liner perforation, ZMI would undertake an expanded and more rigorous analysis of heap detoxification, to include additional sampling and monitoring requirements, water level measurements monthly, and agency notification. (3, 5, 6, 7)

- An expanded reclamation quality control program would be implemented to include such items as particle size restrictions for clay used in reclamation clay installation procedures, foundation preparation, testing of placed materials, inspection requirements, and construction reporting. (5, 6)

- All drainage and diversion ditches, and seepage water capture and treatment systems, would be sized to handle a 6.33 inch, 24-hour storm event with 1 foot of freeboard. (3, 5, 6, 7)

- For reclamation material haul trips using convoys that are routed through the communities of Zortman or Landusky, pilot cars would escort the convoys over the entire length of the haul routes and the speed of the convoys would be reduced to 15 mph. (3, 5, 6, 7)

- To the extent practicable, reclaimed facilities would be recontoured to provide a topography that blends into the surrounding landscape. Straight edges would be rounded. Large, flat surface areas would be broken with changes in contour resembling natural drainage patterns. The objective would be for the post-reclamation topography of the spent ore heaps and/or pits to meet VRM Class II criteria. ZMI would submit recontouring plans for review and comment prior to implementation. (5, 6, 7)

- Past and future impacts to wetland and non-wetland waters of the U.S. would be mitigated by implementing an Aquatic Ecosystem Mitigation Plan, similar to the plan for Alternative 7 in Appendix F of the EIS. (4, 5, 6, 7)

Zortman Mine Mitigations

- The 80-million ton capacity heap leaching facility would be constructed in Upper Alder Gulch as a valley fill leach pad, rather than at Goslin Flats. (5)

- The ore crushing facility would be sited in the vicinity of the pit complex. (5)

- Crushed ore would be transported to the heap leach pad by truck (rather than by conveyor system). (5)

- The 60-million tons of waste rock would be placed in a repository constructed on the Ruby Flats, just east of the Goslin Flats heap leach pad. (6)

- The waste rock repository would be lined on the bottom with a solution detection and collection system to reduce the potential for contamination of area water resources. (6)

- Rerouting of Phillips County Seven Mile Road around the Ruby Flats waste rock repository. (6)

- The Thermopolis shale could not be used without restriction in construction or reclamation purposes. Under-drains for the leach pad would have to be constructed using the native calcareous subsoil material or unmineralized limestones or carbonates from other sources. (5, 6, 7)

- The waste rock repository would be constructed mostly on existing facilities around the Zortman pit complex, rather than in Carter Gulch. (7)

- More rigorous construction quality control procedures would be applied to the leach pad construction. (5, 6, 7)

- The tailing in Ruby Gulch above the town of Zortman would be removed from the drainage and used in reclamation or construction. The drainage would be restored as mitigation for existing disturbance to waters of the United States by other Zortman and Landusky mines facilities. (3, 5, 6, 7)

- The Zortman Mine pits would be backfilled to a level which would allow free drainage of surface water, without impoundment in the pit, into the Ruby Gulch drainage. (3, 5, 6, 7)

- After detoxification, portions of the 85/86 leach pad and dike would be removed to create a free draining surface and placed in the pit as backfill material prior to pit floor reclamation. (3, 5, 6)

- The OK waste rock dump would be removed and used to backfill the pit complex or used as reclamation material. Cover soil would be re-salvaged and the waste rock footprint reclaimed. (3)

- The existing Alder Gulch waste rock dump would be removed and used to backfill the pit complex. The cover soil would be re-salvaged and the waste rock footprint reclaimed using this material. (3)

- The sulfide storage area would also be removed and used as backfill in the pit complex. (3)

- After detoxification, the Zortman 85/86 leach pad and dike would be removed to create a free draining surface to Ruby Gulch and placed in the pit as backfill material above the water table. The 85/86 leach pad footprint would become part of the new waste rock repository. (7)

- The OK and Upper Alder Gulch waste rock dumps would be removed and used to backfill the pit complex, or leached to remove precious metals. Cover soil would be re-salvaged and the waste rock footprints reclaimed. (5, 6, 7)

- The sulfide storage area would also be removed and leached to remove precious metals. (5, 6, 7)

- An alternate water source for bats (or other wildlife) would be constructed in Goslin Gulch between Azure Cave and the leach pad site to mitigate potential loss of wildlife drinking water on Goslin Flats. (6, 7)

- The 89 leach pad dike would be tested for sulfur content as described in Section 2.8.2.2, and re-reclaimed if sulfur exceeds 0.5 percent in more than 10 percent of the material tested. (5, 6, 7)

- To reduce visual impacts observed from areas north of the mine, the north/northwest facing pit highwalls would be reduced to an overall 3:1 slope, with vertical faces reduced such that no slopes are steeper than 2:1. (5, 6, 7)

- To maintain air emissions below the 24-Hour standard for particulates, the number of reclamation haul truck trips passing through the town of Zortman would be limited to 120 in a single day. (7)

Landusky Mine Mitigations

- Highwall runoff would be diverted from the mine pits into Montana Gulch and treated if necessary. (3, 5, 6, 7)

- The Landusky 91 leach pad dike would be re-reclaimed as appropriate to allow redistribution of spent ore to the south, west and east of the 87/91 pad. This action would eliminate the potential for surface water from the 87/91 pad to runoff north of the mine site into drainages on the Fort Belknap Indian Reservation. (3, 5, 6, 7)

- Existing reclamation covers on the Gold Bug waste rock repository and the Mill Gulch waste rock dump may require supplemental cover soil to limit infiltration. (3, 5, 6, 7)

- To unblock surface water drainage in the western tributary of Montana Gulch a drainage channel would be constructed along the west margin of the 85/86 leach pad. (3, 5, 6, 7)

- The Landusky Mine pit complex would be backfilled to a minimum elevation of 4,740 feet (at the south end of the pit complex/drainage ditch) to create a surface which would freely drain into Montana Gulch, thereby reducing the potential for precipitation and surface water runon to infiltrate through acidic materials and into the groundwater. Material used in backfill would come from existing waste rock dumps and leach pads, mined waste rock, or drainage channel construction. (3, 6, 7)

- Runoff from the Landusky Mine pit complex would be directed to Montana Gulch, immediately below the waste rock dump, by constructing a drainage notch between the August/Little Ben pit and Montana Gulch. This action would prevent pit water from flowing into the August tunnel. (3, 6, 7)

- The Landusky Mine pit complex would be backfilled to approximately 4,850 feet (at the midpoint of the drainage) or the minimum elevation necessary to create a surface which would freely drain into King Creek. Sources of pit backfill would include the Montana Gulch waste rock dump and the 85/86 heap leach pad. (5)

- Contingency water capture systems and settling ponds would be installed in upper King Creek to treat surface water runoff from the backfilled pit floors. (5)

PREFERRED ALTERNATIVE

There are two decisions that need to be made. One, how to mitigate environmental impacts from existing mine operations. Two, whether ZMI's proposed plans for expanded mining and mineral recovery are adequate to meet state and federal requirements, and if not, to identify mitigating measures that would be needed to meet these requirements. The two decision processes are related in that if expansion is approved it creates some additional options for dealing with impacts from existing mine operations. This does not mean that mine expansion is needed to mitigate existing impacts, just that mitigation could be accomplished differently if done in conjunction with mine expansion.

Alternative 7 has been *identified* as the agencies' (BLM and DEQ) preferred alternative. Alternative 7 satisfies the purpose and needs described in Chapter 1.

Of the seven alternatives in this Final EIS, a mine expansion alternative has been identified to meet the need for providing ZMI a means to develop precious metal deposits at the Zortman and Landusky mines and reclaim both mine facilities. Of the various possible waste rock and leach pad facility locations for mine expansion at the Zortman Mine, Alternative 7 is preferred.

Preferred reclamation measures are described under Alternative 7. Modified reclamation covers have been developed to enhance the potential for long-term reclamation success and reduce the potential for surface water to infiltrate into capped facilities. These measures, together with the other mitigations detailed in Alternative 7, would be used to address existing environmental problems, prevent unnecessary or undue degradation, and provide for comparable stability and utility of mined lands with adjacent areas.

No sooner than 30-days after this Final EIS is released, a Record of Decision (ROD) will be prepared (see Figure 1-5 of the final EIS). The ROD will consider the results of this Final EIS along with the implementation factors and options to *select* a preferred alternative.

Once selected, an alternative may be implemented in various ways. The alternative could be fully implemented, separate decisions could be issued for either of the mines, or implementation of mine expansion could be phased contingent on performance of certain corrective measures. The impact analysis presented in Chapter 4 is based on full implementation of each alternative described in Chapter 2. Implementation of the selected alternative will be decided in the ROD.

During implementation of the decision, the mine operator (ZMI) could propose waivers, exceptions, or modifications be made to the selected alternative. The purpose of this flexibility is to allow consideration of alternative mitigation technologies that may be developed during the life of the project, and to provide for changes that may be warranted due to better knowledge of site conditions gained during operations.

Any changes in operating practices, reclamation design, or mitigating measures would be reviewed by the agencies and accepted if they provide equal or greater resource protection than the original requirement, and did not result in significant impacts previously unidentified by this EIS. Proposed changes which would not achieve the same level of resource protection, or would result in previously undisclosed significant impacts, would require supplemental analysis under NEPA and MEPA prior to approval.

AFFECTED ENVIRONMENT

Chapter 3 of the EIS describes the natural resources and economic and social conditions found in the study area. Following is a brief summary of this affected environment.

The proposed project is located in the Little Rocky Mountains of north-central Montana, near the southern boundary of the Fort Belknap Indian Reservation in the southwest corner of Phillips County. Nearby towns include Hays and Lodgepole (in the southern portion of the Reservation), Landusky (approximately 0.5 miles south of the Landusky Mine), and Zortman (about 1 mile south of the Zortman Mine).

The study area is characterized by rolling prairie dissected by streams and interrupted by "island mountains" that rise out of the relatively flat plains like islands in the ocean. Elevations range from approximately 2,300 feet above sea level at Fort Peck Lake east of the Little Rocky Mountains, to 5,700 feet above sea level at Old Scraggy Peak, located approximately 1.5 miles east of the Zortman Mine. Topography within the mountains is rugged, with high outcrops and steep v-shaped valleys. Mining in the Little Rocky Mountains can be characterized as heavy during the 1800s through the turn of the century, cyclical from the 1920s through the 1940s, and sporadic through 1951. After 1951, little serious activity occurred in the Little Rocky Mountains until modern surface-mining operations were initiated in 1979.

Soil resources include young and relatively undeveloped soil in the mountain areas, and more developed soil in the plains areas, which are potential major sources of reclamation cover soil and subsoil.

Portions of the project area that have not been mined are mostly forested. Primary community types present include lodgepole pine forest, ponderosa pine forest, Douglas fir forest, deciduous tree forest, grassland, shrubland, and outcrop/scree communities. Small wetlands occur along the lower drainages. The area supports a wide variety of plants, and the Little Rocky Mountains are a source of plant materials for ethnobotanical uses. No plants listed as federally threatened or endangered or as of special interest or concern by the State of Montana are known to occur within the study area. A wide variety of wildlife species can also be found. Well-known species include big game animals, upland game birds, raptors, and bats. Eighteen species of special concern at either the federal and/or state level may potentially occur in the region.

The headwaters of several streams are located in the study area; most streams are ephemeral or intermittent in nature. These drainages and the subsurface aquifers in the area have been or can be affected by acid rock drainage associated with mining activities in this highly mineralized area. Surface water and groundwater have exhibited elevated chemical concentrations on specific occasions downstream as far as Zortman and Landusky since 1979. Water treatment systems are currently operating in all of the affected drainages, and significant improvement in downstream water quality has been observed.

The economy of the area is based primarily on the use of natural resources, which includes agriculture, mining, and outdoor recreation. Agriculture is the predominant land use in the study area. Public lands provide both developed and dispersed recreation opportunities. Fort Belknap Indian Reservation also provides some recreational facilities including Pow Wow grounds.

The affected environment for the Little Rocky Mountains includes both its spiritual and physical characteristics which are traditionally seen as inseparable. The mountains are viewed as one of the last refuges where traditionalists can practice spiritual activities such as prayer, fasting, and making offerings. A number of Native Americans have used the Little Rocky Mountains for subsistence, social, and religious activities, and the Little Rocky Mountains are considered eligible for listing on the National Register of Historic Places as a Traditional Cultural Property. The Alder Gulch Historic District, which contains historic mining remains, is also considered eligible for the National Register.

Other areas are recognized as Areas of Critical Environmental Concern (ACEC). These include Azure Cave and prairie dog towns 20 miles east of the Little Rocky Mountains. Three other areas nominated for ACEC consideration include Little Rocky Mountains, Saddle Butte, and Old Scraggy Peak.

ENVIRONMENTAL CONSEQUENCES

The seven alternatives were evaluated for their potential impact on various environmental, social, and cultural resources. A detailed discussion of these impacts, or environmental consequences, is contained in Chapter 4 of the Final EIS. The following discussions highlight the EIS material, with emphasis on the most significant impacts, especially impacts associated with the four primary issues of concern previously discussed: water quality, reclamation and its associated impacts, cultural resources, and socioeconomics.

The summary of impacts is presented in two ways. The first summary is a discussion of the relative impacts each alternative would have on an environmental resource. This provides a concise assessment of how well each alternative would prevent or mitigate impacts to each resource. The second portion of this section describes the impacts by alternative using a comprehensive summary table. This presents a comparative description of the resource impacts relating to implementation of each alternative.

Summary of Resource Impacts

This section summarizes the information presented in Chapter 4 of the Final EIS. The impacts to each environmental resource are described and, where possible, compared to discern relative differences in significance.

Geology and Topography

Mining in the Little Rocky Mountains during the past sixteen years has irreversibly altered the landscape and consumed local geologic resources. Approximately 20 million tons of gold and silver bearing ore have been removed from the Zortman Mine during the years 1979 to 1995, and about 110 million tons of ore have been removed from the Landusky Mine during the same years. It is estimated that about 1.4 million ounces of gold and 5.5 million ounces of silver have been recovered from that ore during the years 1979 through

1995. Other geologic resources, including clay and limestone, have been used in construction and reclamation at the mines.

Ore and waste rock removal has significantly altered the local topography of the southern portion of the Little Rocky Mountains. The most dramatic and significant impact to topography is the result of hardrock mining in the ore zones at both mines. The elevation of the pre-mining land surface at the current Zortman Mine pit was over 5,200 feet mean sea level (msl). Since large-scale mining began, two prominent hills have been reduced in elevation by 200 feet or more to an existing ground surface less than 5,000 feet msl in some areas. Topographic alteration to the Landusky Mine landscape has been greater than at Zortman because about five times as much ore and waste rock has been removed during the past 16 years of mining. The elevation of the pre-mining land surface at the current Landusky Mine pit was about 5,400 feet msl at the highest point. Up to 500 feet of relief has been removed as a result of large-scale mining.

Impacts to geologic resources and topography from the alternatives may be distinguished first by whether future mining would take place. No significant impact to geologic resources would occur for the non-expansion alternatives (1 through 3). No new ore would be mined and the only additional geologic resources consumed would be clay for use in reclamation covers. Alternative 3 would result in a significant new disturbance at Goslin Flats to provide material for use in reclamation covers. Topography would change little for any of the non-expansion alternatives, although Alternative 3 would require that facility slopes be reduced. This action would increase stability and reduce risks of facility failure. Mine pits would be partially backfilled with material from existing dumps and pad, to some extent reducing the magnitude of topographic impacts from past mining actions.

For all expansion alternatives, approximately 80 million tons of ore and 60 million tons of waste rock would be generated from the Zortman Mine, and about 7.6 million tons of ore and 7 million tons of waste rock would be generated at the Landusky Mine. Impacts to other geologic resources would vary between the alternatives. Alternatives 5 and 6 would require the use of more clay than Alternative 4, and Alternative 7 would use significantly less clay than any of the other expansion alternatives.

Topographic modifications would vary somewhat among expansion alternatives. Significant new disturbance would occur in the Goslin Flats area under Alternatives 4, 6, and 7 from leach pad construction and operation. Alternative 6 would have even greater impact on this area because the waste rock facility would be constructed on Ruby Flats. Alternatives 5, 6, and 7 would reduce the magnitude of past topographic impact and lessen geologic hazards by the removal of some existing facilities, and resloping of reclaimed areas to 3:1 where possible.

Water Resources

Non-Expansion Alternatives: Infiltration modeling of the non-expansion alternatives shows that Alternative 3 would provide the best long-term barrier to infiltration. The following average percentages of available precipitation are predicted to infiltrate into facilities over the first 20 years of reclamation:

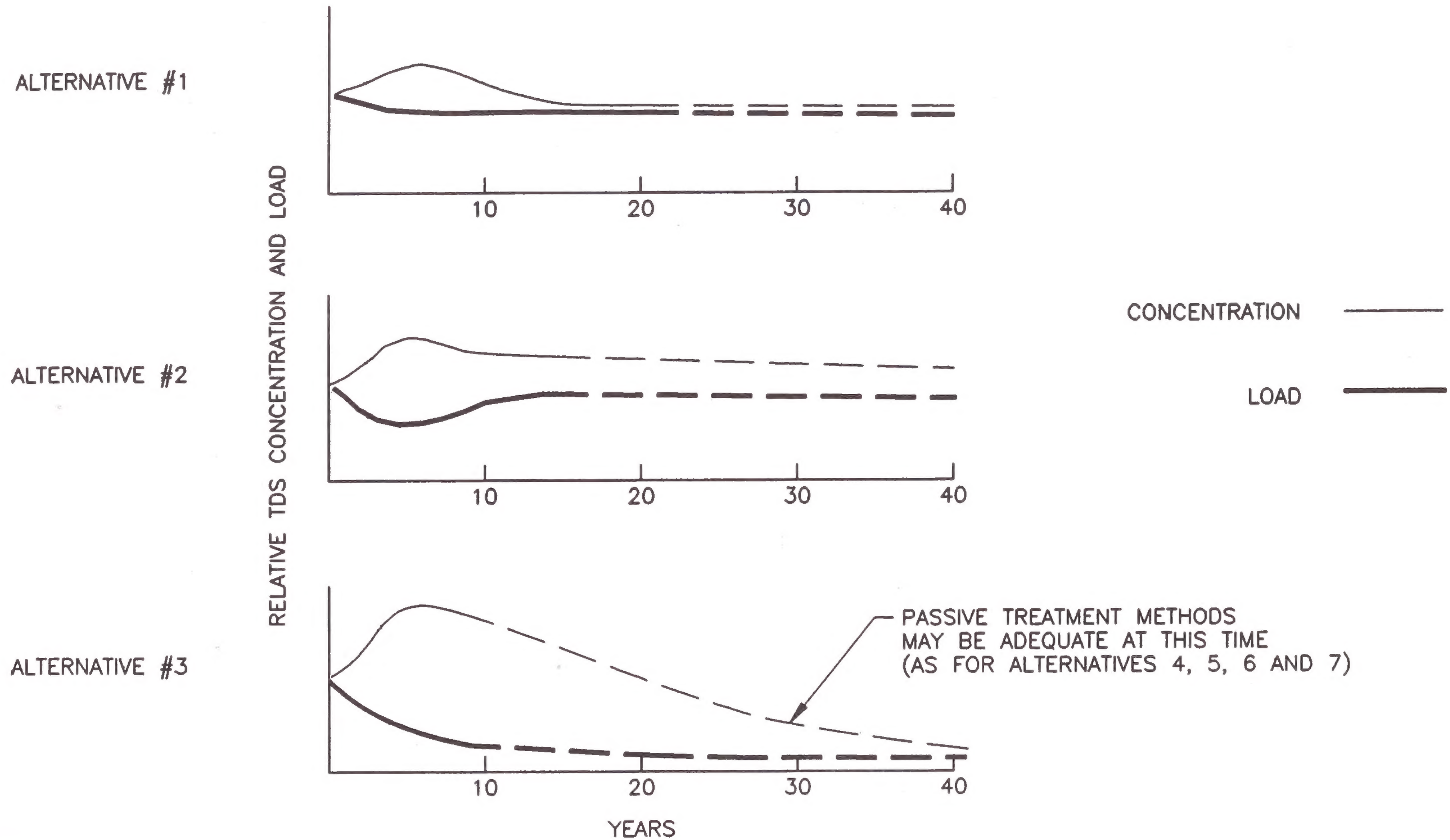
	Flat Area	Side Slopes
• Alternative 1	23%	23%
• Alternative 2	23%	23%
• Alternative 3	8%	11%

Total estimated annual average volumes of drainage that would require capture and treatment at the Zortman and Landusky mines in the short-term (approximately 20 years) are:

- Alternative 1: 378 to 450 gpm
- Alternative 2: 348 to 419 gpm
- Alternative 3: 211 to 284 gpm

Figure ES-2 schematically summarizes the long-term trends in relative total dissolved solids (an indicator of overall water quality) concentrations and loads seeping from facilities. The major points to be noted regarding the three non-expansion alternatives are:

- Under Alternative 1, water quality conditions are expected in the long-term to remain similar to what is presently observed.
- Alternative 2 is expected to provide a short-term barrier to infiltration where the 6-inch clay cap is applied, causing short-term increases in concentration and decreases in loads. However, because the long-term reliability of the clay cap is questionable, long-term water quality may return to conditions similar to those presently observed.



NOTE:
TDS AS SHOWN IS MEANT TO BE REPRESENTATIVE OF TOTAL WATER QUALITY INCLUDING SULFATE, METALS ETC.

Job No. :	23173E
Prepared by : I.R.F	
Date :	12/29/94

ESTIMATED LONG-TERM POST RECLAMATION WATER QUALITY FOR NON EXPANSION ALTERNATIVES 1, 2 AND 3

FIG. ES-2

- As part of Alternative 3, the Alder Gulch waste rock dump and the 85/86 leach pad and dike would be removed from southern drainages of the Zortman Mine. This would improve water quality in those drainages.

- Alternative 3 provides water balance and geosynthetic clay liner (GCL) barrier reclamation covers which efficiently reduce infiltration into the underlying facilities by enhancing the evapotranspiration of water held in storage by the significant thickness of soil. The GCL covers provide a low permeability barrier, which enhances lateral drainage and is not as susceptible to desiccation from freeze thawing or dehydration as compacted clay. This should provide better long-term performance at limiting infiltration.

- Under Alternative 3, short-term concentrations are expected to increase and loads are expected to reduce rapidly. In the long-term, the facilities are expected to reach static hydraulic conditions (little discharge), which would inhibit the generation and transportation of acid rock drainage.

In summary, among the non-expansion alternatives only under Alternative 3 would there be any opportunity to shut down active treatment of seepage, and replace it with passive treatment systems. However, Alternative 3 still has the potential to require long-term capture and treatment.

Expansion Alternatives: Infiltration modeling of Alternatives, 4, 5, 6, and 7 shows all four to result in the similar percentage of infiltration on facility side slopes. Although the water barrier covers proposed in Alternative 4, 5, and 6 appear to attain the best or smallest amount of infiltration into the facilities, in the short- to mid-term; it is anticipated that the long-term integrity of the reclamation covers proposed in Alternative 7 would be better.

The following average percentages of available precipitation are predicted to infiltrate into the facilities.

		Side Slopes	
	Flat Area	3:1	2:1
• Alternative 4	0.03%	7.8%	8.0%
• Alternative 5	0.005%	7.8%	-
• Alternative 6	0.005%	7.8%	-
• Alternative 7	8.0%	10.5%	-

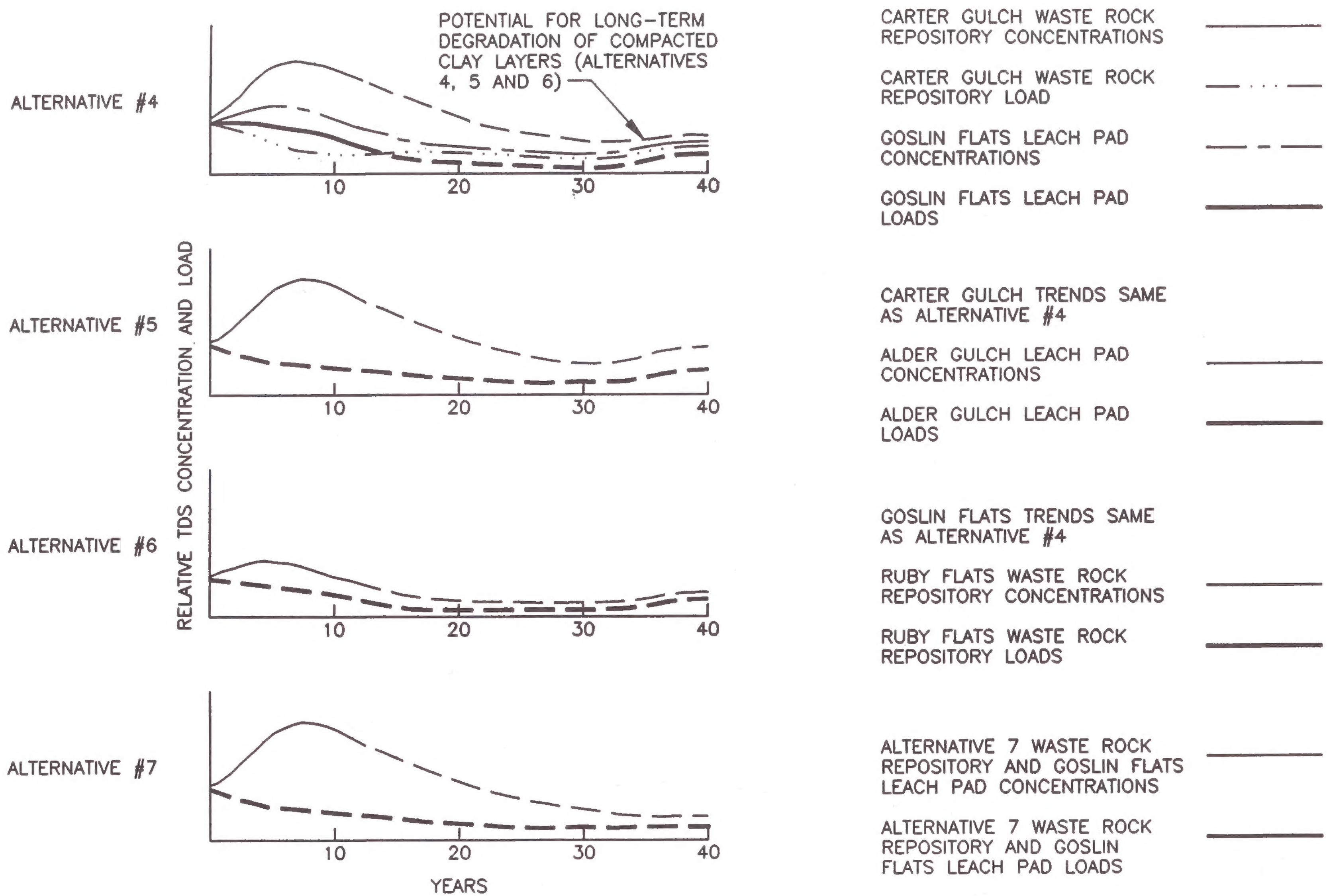
Estimated total average volumes requiring capture and treatment in the short-term (approximately 20 years) are:

- Alternative 4: 307 to 389 gpm
- Alternative 5: 322 to 423 gpm
- Alternative 6: 244 to 313 gpm
- Alternative 7: 258 to 321 gpm

The PVC/clay composite covers proposed for Alternatives 4, 5, and 6 obtain a lower infiltration rate than the GCL barrier covers proposed for Alternative 7. However, Alternative 7 avoids many other impacts associated with mining and hauling the clay needed for Reclamation Covers B, C, and Modified C. Also, the success of these reclamation covers does not rely on a high degree of Quality Assurance and Quality Control (QA/QC). Finally, the long-term integrity of the Alternative 7 reclamation cover is greater since they do not rely on compacted clay, which may desiccate over time. Figure ES-3 schematically summarizes the expected long-term trends in relative TDS concentrations and loads seeping from facilities. The major points to be noted regarding the four expansion alternatives are:

- Alternative 4 places the leach pad on Goslin Flats and the waste rock repository in Carter Gulch. The long-term reduction of acid rock drainage generation is expected to be effective at the Goslin Flats facility, as it would eventually drain, becoming "high and dry." Water quality management would be difficult for a waste rock repository constructed in Carter Gulch with underdrainage providing an ongoing source of oxygen and water to transport acid rock drainage, thereby reducing the effectiveness of its enhanced reclamation cover in the long-term.

- Alternative 5 places both the leach pad and the waste rock repository within the Alder Gulch



NOTES:

1. TDS AS SHOWN IS MEANT TO BE REPRESENTATIVE OF TOTAL WATER QUALITY INCLUDING SULFATE, METALS, ETC.
2. EXISTING FACILITIES WOULD HAVE SOME LONG-TERM WATER QUALITY TRENDS AS SHOWN IN ALTERNATIVE #3 (FIGURE 4.2-1)

ESTIMATED POST RECLAMATION WATER QUALITY FOR EXPANSION ALTERNATIVES 4, 5, 6, AND 7

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FIG. ES-3

drainage. Although a significant reduction of infiltration and resultant acid rock drainage generation is expected, underdrainage would likely provide a significant source of acid rock drainage in the long-term. Construction of both facilities in this steep drainage with near perennial flow and sulfide rich bedrock also increases the potential for downstream impacts to water quality and constitutes a significant loss of high quality water resources.

- Alternative 6 places both the leach pad and the waste rock repository on Goslin Flats. Construction on flat land above the water table, combined with the proposed enhanced reclamation covers, is expected to allow both facilities to drain, essentially becoming "high and dry." The flat topography and resultant flat hydraulic gradient underlying these facilities would also allow effective monitoring and recovery of any unforeseen seepage from the facilities. Soil salvaging within the footprint of these facilities is expected to generate some short-term periods of elevated suspended solids in the surrounding drainages.

- Alternative 7 places the leach pad on the flats above the water table in an environment suited for effective, water quality management. It also places the waste rock repository on top of existing waste rock piles, leach pads and pits. This location creates little additional disturbance, concentrates the impact in drainage systems with existing mitigation measures and provides the reclamation cover required for the majority of the existing Zortman mine facilities. The combination of water barrier and water balance type-reclamation covers proposed with this alternative reduces infiltration and the volumes requiring treatment, but do not preclude the possible need for long-term capture and treatment of impacted waters.

In summary, under all four expansion alternatives, there is potential to scale down treatment of seepage at some point in the future. The long-term effectiveness of the enhanced reclamation covers is, however, better on the flat terrain surrounding the Little Rocky Mountains where the facilities would eventually drain in a controlled manner becoming "high and dry."

Implementation of the water control, capture and treatment measures described in Appendix A would cause mine discharges to achieve compliance with water quality standards. However, by incorporating selective waste rock handling, runon and runoff controls, and enhanced reclamation covers into the mine plan, the reliance on water capture and treatment to meet the discharge limits is minimized. Likewise, the consequences of a system failure in the water capture and treatment systems are reduced where source control has first been employed to limit the volume and contaminant load of water that must be treated. Therefore, long-term protection of water quality is most reliable when ARD source control measures are used in conjunction with seepage capture and treatment. This balance between ARD source control and water treatment is attained by Alternatives 3 and 7. Alternatives 4, 5, and 6 would be less balanced, but still effective. Alternatives 1 and 2 would depend heavily upon water capture and treatment to achieve and maintain water quality standards at the point of compliance. These two alternatives would have the least long-term reliability.

Soil and Reclamation Effectiveness

Past exploration and mining-related activities has resulted in the disturbance and alteration of in-place, natural soil in both the Zortman and Landusky mine areas. Direct negative effects on soil that have resulted from exploration, and the construction and operation of mine-related facilities include the following:

- Loss/interruption of pedogenic (soil) development, including breakdown of soil structure and mixing of distinct soil horizons

- Loss of soil material due to disturbance and exposure to forces of erosion

- Alteration of biological and nutrient conditions in soil materials stored in piles for extended periods

- Compaction of soil materials beneath facilities and in areas of natural soil crossed by vehicular traffic

- Loss or reduction of soil productivity

Direct impacts to soil from the period of large-scale mining, 1979 to the present, are classified as high.

Criteria to determine impacts to soil and reclamation success from alternative actions include:

- Restoration of less than 48 inches of suitable material, including at least 12 inches of cover soil, on final reclamation grades/surfaces to serve as an effective long-term plant growth medium.

- Soil loss as predicted by the Revised Universal Soil Loss Equation (RUSLE) (Renard et al. 1991) in excess of 2 tons/acre/year for reclaimed slopes and surfaces (EPA 1991, Richardson 1995).

Table ES-3 summarizes the amount of soil projected to be lost from the major facilities for each alternative. Soil loss on sideslopes would exceed significance criteria in the short-term for all of the alternatives. Of the non-expansion alternatives, only Alternative 3 reclamation measures would result in soil loss less than 2 tons/acre/year in the long term. Alternative 3 is also the only non-expansion alternative to provide 48 inches of cover as vegetative growth media over materials potentially acid generating. Therefore, potential for reclamation success in the long-term would be greatly increased under Alternative 3 as opposed to Alternatives 1 or 2. Alternative 3 would require more disturbance to be reclaimed than the other two non-expansion alternatives.

Soil loss estimated for Alternatives 4, 5, and 6 is roughly comparable, since these expansion alternatives use essentially the same type of reclamation covers and reclamation cover thickness. Because of the different reclamation cover employed, soil loss on relatively flat slopes would be greater under Alternative 7 than for the other expansion alternatives. However, long-term soil loss from side slopes, which constitute most of the disturbance to be reclaimed, would be at least 20 percent and in many cases 100 percent less than for Alternatives 4, 5, and 6. Disturbance associated with Alternative 7 would be approximately 10 percent less than for the other expansion alternatives.

Comparable stability and utility of most facilities would be achieved in the long-term for all of the expansion alternatives and Alternative 3. Alternatives 1 and 2 would likely not meet this statutory requirement due to the ineffectiveness of reclamation measures.

Vegetation and Waters of the U.S.

Impacts to vegetation were assessed based on the following factors:

- the loss of species diversity in disturbed areas,
- disturbance of threatened, endangered, or sensitive plant species or communities,
- the loss of sole sources of vegetation used by Native Americans for ceremonies, medicine, and food,
- the loss of riparian vegetation and habitat,
- the long-term loss of trees/forestry resources, and
- adequacy of the proposed reclamation programs to achieve an adequate environment for natural plant succession and return the vegetation on the site to pre-mining levels of canopy cover, productivity, and utility.

In the short-term, the loss of plant diversity in disturbed areas would be considered a significant impact for all alternatives because revegetation efforts would replace only about 8 percent of the species that naturally occur on the site.

There would be no impacts to threatened, endangered, or sensitive plant species or communities under any of the alternatives, nor any impacts to sole sources of vegetation used by the Native Americans.

Disturbance to riparian habitat would affect less than one percent of all riparian habitat in the study area for all alternatives except Alternative 5, which would affect approximately two percent of the riparian habitat in the study area. Based on the significance criteria, impacts are rated low. However, impacts to 17 acres of high quality riparian habitat in Upper Alter Gulch, as proposed in Alternative 5, could be considered significant locally. This alternative would eliminate a very diverse riparian community that provides good wildlife habitat and is relatively uncommon in the area.

Impacts to all vegetation resources were evaluated including those to grasslands, shrublands, as well as forested habitat. The loss of forest habitat would be considered the most significant though, due to the amount of time (70-80 years) necessary to regenerate stands of comparable utility (e.g., merchantable timber, wildlife cover, and visual screening of disturbances). The acreage of direct impacts to forest habitat was calculated for each alternative. Mining activities between 1979 and the present have been significant. Alternatives 1 and 2 would not result in any additional impacts to the forests, and Alternative 3 would affect 5 additional acres. For the expansion alternatives 4 through 7, acres of disturbance of forested habitat range from 216 (Alternative 6) to 521 (Alternative 5), and impacts would be moderate.

The proposed reclamation plan for each alternative was evaluated for its ability to achieve an adequate environment for natural plant succession that could be expected to be sustained in the long-term, and return the site to similar, pre-mining conditions. The reclamation plans proposed under Alternatives 1 and 2 would not be adequate to protect soils from erosion and acidification, and result in significant impacts to vegetation and failure of reclamation efforts over much of the disturbed area. Alternatives 3 and 7 include reclamation plans which would minimize erosion, prevent acidification of the soils, and would be capable of sustaining natural plant succession and productivity into the future. A minimal amount of revegetation failure would be expected and impacts would be low. The reclamation plans proposed under Alternatives 4 through 6 are better than those for Alternatives 1 and 2,

TABLE ES-3
SUMMARY OF SOIL LOSS RATE FOR EACH ALTERNATIVE AND MAJOR FACILITIES AT ZORTMAN AND LANDUSKY MINES(1)

	Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5		Alternative 6		Alternative 7	
Facility	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)
Zortman														
• 79/80/81 Pad													N/A	N/A
- Sideslopes	6.12	2.40	6.12	2.40	3.53	0.82	3.13	1.04	3.13	1.04	3.13	1.04		
- Top Areas	0.15	0.06	0.15	0.06	1.58	0.46	0.10	0.03	0.10	0.03	0.10	0.03		
• 82 Pad													N/A	N/A
- Sideslopes	6.12	2.40	6.12	2.40	3.53	0.82	3.13	1.04	3.13	1.04	3.13	1.04		
- Top Areas	0.19	0.08	0.19	0.08	1.58	0.46	0.13	0.03	0.13	0.03	0.13	0.03		
• 83 Pad													N/A	N/A
- Sideslopes	6.12	2.40	6.12	2.40	3.53	0.82	3.13	1.04	3.13	1.04	3.13	1.04		
- Top Areas	0.21	0.09	0.21	0.09	1.58	0.46	0.14	0.04	0.14	0.04	0.14	0.04		
• 84 Pad													N/A	N/A
- Sideslopes	6.12	2.40	6.12	2.40	3.53	0.82	3.13	1.04	3.13	1.04	3.13	1.04		
- Top Areas	0.23	0.10	0.23	0.10	1.58	0.46	0.16	0.04	0.16	0.04	0.16	0.04		
• 85/86 Pad														
- Sideslopes	6.12	2.40	6.12	2.40	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
- Top Areas	0.22	0.09	0.22	0.09										
• 89 Pad													N/A	N/A
- Sideslopes	6.12	2.40	6.12	2.40	3.53	0.82	3.13	1.04	3.13	1.04	3.13	1.04		
- Top Areas	0.19	0.08	0.19	0.08	1.58	0.46	0.13	0.03	0.13	0.03	0.13	0.03		
• Alder Gulch WRD														
- Sideslopes	6.06	2.37	6.06	2.37	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
- Top Areas	0.22	0.09	0.22	0.09										
• OK WRD					N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
- Sideslopes	6.12	2.40	6.12	2.40										
- Top Areas	0.19	0.08	0.19	0.08										
• Goslin Flats Pad														
- Sideslopes	N/A	N/A	N/A	N/A	N/A	N/A	3.74	1.25	N/A	N/A	3.74	1.25	3.53	0.82
- Top Areas							0.24	0.06			0.24	0.06	1.58	0.46

TABLE ES-3 - SUMMARY OF SOIL LOSS RATE FOR EACH ALTERNATIVE
(Continued)

	Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5		Alternative 6		Alternative 7	
Facility	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)
• Carter Gulch WRR - Sideslopes - Top Areas	N/A	N/A	N/A	N/A	N/A	N/A	4.48 0.23	1.50 0.06	3.13 0.23	1.04 0.06	N/A	N/A	N/A	N/A
• Upper Alder Gulch Pad - Sideslopes - Top Areas	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.13 0.31	1.04 0.08	N/A	N/A	N/A	N/A
• Ruby Flats WRR - Sideslopes - Top Areas	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.13 0.24	1.04 0.06	N/A	N/A
• Alt. #7 WRC - Sideslopes - Top Areas	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.53 1.58	0.82 0.46
Landusky • 79 Pad - Sideslopes - Top Areas	6.12 0.15	2.40 0.06	6.12 0.14	2.40 0.05	3.53 1.58	0.82 0.46	3.13 0.10	1.04 0.03	3.13 0.10	1.04 0.03	3.13 0.10	1.04 0.03	3.53 1.58	0.82 0.46
• 80/82 Pad - Sideslopes - Top Areas	6.12 0.17	2.40 0.07	6.12 0.15	2.40 0.06	3.53 1.58	0.82 0.46	3.13 0.12	1.04 0.03	3.13 0.12	1.04 0.03	3.13 0.12	1.04 0.03	3.53 1.58	0.82 0.46
• 83 Pad - Sideslopes - Top Areas	6.12 0.15	2.40 0.06	6.12 0.14	2.40 0.05	3.53 1.58	0.82 0.46	3.13 0.10	1.04 0.03	3.13 0.10	1.04 0.03	3.13 0.10	1.04 0.03	3.53 1.58	0.82 0.46
• 84 Pad - Sideslopes - Top Areas	6.12 0.16	2.40 0.07	6.12 0.14	2.40 0.05	3.53 1.58	0.82 0.46	3.13 0.11	1.04 0.03	3.13 0.11	1.04 0.03	3.13 0.11	1.04 0.03	3.53 1.58	0.82 0.46
• 85/86 Pad - Sideslopes - Top Areas	6.12 0.18	2.40 0.08	6.12 0.16	2.40 0.06	3.53 1.58	0.82 0.46	3.13 0.12	1.04 0.03	3.13 0.12	1.04 0.03	3.13 0.12	1.04 0.03	3.53 1.58	0.82 0.46

TABLE ES-3 - SUMMARY OF SOIL LOSS RATE FOR EACH ALTERNATIVE (Concluded)

	Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5		Alternative 6		Alternative 7	
Facility	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)	Short Term (Tons/ Ac/Yr)	Long Term (Tons/ Ac/Yr)
• 87/91 Pad														
- Sideslopes	3.89	1.52	3.89	1.52	3.53	0.82	3.13	1.04	3.13	1.04	3.13	1.04	3.53	0.82
- Top Areas	0.18	0.07	0.16	0.06	1.58	0.46	0.12	0.03	0.12	0.03	0.12	0.03	1.58	0.46
• Gold Bug WRD														
- Sideslopes	5.92	2.32	5.92	2.32	4.76	1.59	4.76	1.59	4.76	1.59	4.76	1.59	3.53	0.82
- Top Areas	0.15	0.06	0.14	0.05	0.10	0.03	0.10	0.03	0.10	0.03	0.10	0.03	1.58	0.46
• Mill Gulch WRD														
- Sideslopes	5.75	2.25	5.75	2.25	4.63	1.54	4.63	1.54	4.63	1.54	4.63	1.54	3.53	0.82
- Top Areas	0.17	0.07	0.15	0.06	0.12	0.03	0.12	0.03	0.12	0.03	0.12	0.03	1.58	0.46
• Montana Gulch WRD														
- Sideslopes	6.12	2.40	6.12	2.40	3.53	3.53	3.13	1.04	3.13	1.04	3.13	1.04	3.53	0.82
- Top Areas	0.15	0.06	0.14	0.05	1.58	1.58	0.10	0.03	0.10	0.03	0.10	0.03	1.58	0.46
• Sullivan Park WRD														
- Sideslopes	6.12	2.40	6.12	2.40	4.92	1.64	4.92	1.64	4.92	1.64	4.92	1.64	3.53	0.82
- Top Areas	0.16	0.07	0.14	0.05	0.11	0.03	0.11	0.03	0.11	0.03	0.11	0.03	1.58	0.46
• August #1, #2 WRD														
- Sideslopes	N/A	N/A	N/A	N/A	4.92	1.64	4.92	1.64	4.92	1.64	4.92	1.64	3.53	0.82
- Top Areas					0.10	0.03	0.10	0.03	0.10	0.03	0.10	0.03	1.58	0.46

*(1) A detailed presentation of the RUSLE calculations for the major Zortman and Landusky Mine Facilities is available in the Agencies' project file.

A rate of soil loss in excess of 2 tons/acre/year from reclaimed slopes and surfaces would be a significant impact (Section 4.3.1).

but not as good as for Alternatives 3 and 7. Some erosion and acidification of soils are expected to result in moderate impacts to vegetation.

Wetland and Non-Wetland Waters: Impacts to wetland and non-wetland waters were assessed for the period 1979-present and for each alternative by calculating acreage of direct and indirect impacts for the individual drainages in the study area. Then, using information from the baseline which indicated the functional "value" of the wetlands and drainages, impacts were rated as high (significant) if they resulted in a more than minimal loss or change in value to either a "high" or "moderate" value drainage or wetland. Mitigation proposed for each alternative was then taken into account, and a final rating was determined.

Alternatives 1 through 3 resulted in very little impact and no pre-mitigation significant impacts to wetlands. Alternatives 1 and 2 involved minor losses for placement of water capture structures only. Alternative 3 included this plus some indirect impacts to low value wetlands in Goslin Flats that would not be mitigated. For the expansion alternatives, Alternatives 4 and 7 are very similar in wetland impacts. They include about one acre of direct loss and approximately ½ acre of indirect impacts in Goslin Flats, and minor acreage of impacts from installation of water capture structures. Alternatives 5 and 6 have high pre-mitigation impacts because of losses in Alder Gulch and Camp Creek, two wetland systems that are of "moderate" value, with Alternative 6 causing the greatest area of disturbance overall. With replacement wetlands mitigation, impacts would be reduced to insignificant levels for all alternatives.

For non-wetland waters, there are significant impacts to several drainages that occurred since 1979, which carry through for all alternatives as potentially significant pre-mitigation impacts. This includes losses of headwaters in Alder Gulch, Montana Gulch, King Creek, and other drainages. For the non-expansion alternatives, these losses plus minor (low to moderate levels) impacts related to construction of water capture and treatment facilities, are the primary non-wetland effects, and all three are very similar. However, with the exception of the inclusion of Ruby Gulch restoration in Alternative 3, none of these provide mitigation for the past direct impacts to non-wetland waters. The water capture and treatment program would mitigate for past indirect water quality impacts.

Impacts to non-wetland waters for the expansion alternatives are greater due to the increase in disturbed area. Alternatives 4 and 7 are similar, and include some high impacts in Alder Gulch and mostly moderate to low impacts elsewhere, for a total of 7.4 acres (Alternative 7) or 7.9 acres (Alternative 4) of new direct fill. Indirect impacts would include approximately 7.3 acres of downstream drainages affected by sedimentation and water quality impacts. Alternative 5 would result in slightly less direct fill and some new indirect impacts in Alder Gulch, which is a "moderate" value resource and has an extensive non-wetland riparian area. Alternative 6 would result in approximately 7 acres of direct fill, but has the most extensive indirect impacts in the Camp Creek/Ruby Gulch areas. For all of the expansion alternatives, a mitigation plan would be required that includes 1.5:1 mitigation for past impacts and 1:1 mitigation for proposed impacts, with emphasis on replacement of lost functions and values, and replacement concurrent with impact (Appendix F). With successful implementation of this plan and the water quality improvement measures, impacts for any of Alternatives 4 through 7 would be reduced to insignificant levels.

Tables ES-4 and ES-5 summarize acreages of direct and indirect impacts to wetland and non-wetland waters for all alternatives. Table ES-6 summarizes impacts to vegetation, wetland waters, and non-wetland waters.

Wildlife and Aquatics

Mine activities have resulted in: 1) an overall loss of wildlife habitat; 2) increased wildlife mortality from mining-related traffic and process ponds; and 3) decreased abundance and diversity of macroinvertebrates from degraded water quality and increased sedimentation.

Existing habitat loss for the non-expansion Alternatives 1 and 2 would be inadequately reclaimed over the long-term, due to steep slopes, erosion, inadequate plant growth media, and acid rock drainage. Mine-related wildlife mortality would return to pre-mining levels as process ponds would be netted and closed, and traffic would cease after reclamation is completed. Water quality and sedimentation impacts on aquatic macroinvertebrates would continue to be moderate to high (significant) in the long-term due to expected acid rock drainage and failed reclamation.

Impacts to threatened, endangered, and sensitive wildlife species (special status species) and raptors would be negligible from Alternatives 1, 2, and 3.

Alternative 3 would disturb an additional 250 acres of wildlife habitat; however, improved reclamation success would re-establish habitat for bighorn sheep and other grassland wildlife species. Water quality and

TABLE ES-4
SUMMARY OF DIRECT IMPACTS TO WATERS OF THE U.S. (ACRES)
ALTERNATIVES 1 THROUGH 7

		Non-wetland				Wetland			
		Existing	Proposed	Total	TOTAL	Existing	Proposed	Total	TOTAL
Alt 1	Zortman	0.84	0.40	1.24	4.21	-	-	-	0.03
	Landusky	2.89	0.08	2.97		-	0.03	0.03	
Alt 2	Zortman	0.84	0.40	1.24	4.21	-	-	-	0.03
	Landusky	2.89	0.08	2.97		-	0.03	0.03	
Alt 3	Zortman	0.84	0.40	1.24	4.21	-	-	-	0.03
	Landusky	2.89	0.08	2.97		-	0.03	0.03	
Alt 4	Zortman	0.84	4.06	4.90	7.87	-	1.06	1.06	1.09
	Landusky	2.89	0.08	2.97		-	0.03	0.03	
Alt 5	Zortman	0.84	2.48	3.32	6.29	-	0.02	0.02	0.05
	Landusky	2.89	0.08	2.97		-	0.03	0.03	
Alt 6	Zortman	0.84	3.26	4.10	7.07	-	1.06	1.06	1.09
	Landusky	2.89	0.08	2.97		-	0.03	0.03	
Alt 7	Zortman	0.84	3.56	4.40	7.37	-	1.06	1.06	1.09
	Landusky	2.89	0.08	2.97		-	0.03	0.03	

TABLE ES-5
SUMMARY OF INDIRECT IMPACTS TO WATERS OF THE U.S. (ACRES)
ALTERNATIVES 1 THROUGH 7

		Non-wetland				Wetland			
		Existing[1]	Proposed[2]	Total	TOTAL[1]	Existing	Proposed	Total	TOTAL
Alt 1	Zortman	3.04	-	-	14.6	-	-	-	-
	Landusky	11.56	-	-		-	-	-	
Alt 2	Zortman	3.04	-	-	14.6	-	-	-	-
	Landusky	11.56	-	-		-	-	-	
Alt 3	Zortman	3.04	0.4	3.44	15.0	-	1.54	1.54	1.54
	Landusky	11.56	-	-		-	-	-	
Alt 4	Zortman	3.04	7.3	10.34	21.9	-	0.48	0.48	0.48
	Landusky	11.56	-	-		-	-	-	
Alt 5	Zortman	3.04	0.4	3.44	15.0	-	0.24	0.24	0.24
	Landusky	11.56	-	-		-	-	-	
Alt 6	Zortman	3.04	8.7	11.74	23.3	-	4.07	4.07	4.07
	Landusky	11.56	-	-		-	-	-	
Alt 7	Zortman	3.04	7.3	10.34	21.9	-	0.48	0.48	0.48
	Landusky	11.56	-	-		-	-	-	

1 The 14.6 acres listed (3.04 and 11.56) is part of a total of 16.0 acres that have been indirectly impacted since 1979. The 14.6 acre figure is what is used for mitigation purposes, based on the Corps of Engineers' regulatory authority.

2 Proposed acreage is that area above and beyond the 14.6 acres that would be affected by new disturbances associated with mine expansion (Alternatives 4-7) or the Goslin Flats borrow area (Alternative 3).

TABLE ES-6
IMPACTS SUMMARY - VEGETATION AND WETLANDS

Resource	Units	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7
Threatened, endangered, sensitive species habitat	Acres	NI	NI	NI	NI	NI	NI	NI
Sole source of vegetation used by Native Americans	Acres	NI	NI	NI	NI	NI	NI	NI
Riparian vegetation[b]	Acres	--/16	--/16	--/16	10/26	27/43	10/26	9/25
Forest[b]	Acres	--/1029 (H)	--/1029 (H)	5/1034 (M)	358/1387 (M)	521/1550 (M)	216/1245 (M)	256/1285 (M)
Species diversity	% loss (in disturbed area)	92	92	92	92	92	92	93
Vegetative Cover	%	< 80	< 80	> 90	80-89	80-89	80-89	> 90
Effect of Reclamation Plan		H	H	L	M	M	M	L
Cumulative Impact Rating - Vegetation		H	H	L	M	M	M	L
Wetland[a] Direct impacts	Acres	0.03	0.03	0.03	1.09	0.05	1.09	1.09
Wetland[a] Indirect impacts	Acres	-	-	1.54	.48	.24	4.07	.48
Non-Wetland waters - Direct Impact[b]	Acres	.48/4.21	.48/4.21	.48/4.21	4.14/7.87	2.59/6.29	3.34/7.07	3.64/7.37
Non-Wetland waters - Indirect Impact[b]	Acres	0/16.0[c]	0/16.0[c]	0.40/16.0[c]	7.3/16.0[c]	0.40/16.0[c]	8.7/16.0[c]	7.3/16.0[c]
Cumulative Impact Rating - Wetlands - Pre-mitigation		L	L	M	M	H	H	M
Cumulative Impact Ratings - Wetlands - Post-mitigation		L	L	M	L	M/L	M/L	L
Cumulative Impact Rating - Non-wetland waters - Pre-mitigation		H	H	H	H	H	H	H
Cumulative Impact Rating - Non-wetland waters - Post-mitigation		H	H	M	M/L	M/L	M/L	M/L

[a] No previous disturbance to wetlands was identified.
[b] X/Y X - Acres disturbed as a result of implementing the alternative
Y - Cumulative acres disturbed - previous and proposed
[c] 16.0 total acres have been indirectly impacts from 1979-present; of this, 14.6 acres is used for mitigation purposes, based on the Corps of Engineers' regulatory authority.

H - High (Significant) Impact
M - Moderate Impact
L - Low Impact
NI - Negligible Impact

sedimentation impacts to aquatic macroinvertebrates would be less than those described for Alternatives 1 and 2 due to improvements in the reclamation cover, benefits of water capture and treatment measures, and limited new disturbance.

All of the expansion alternatives would result in additional loss of wildlife habitat. Alternative 6 would disturb the most additional habitat, while Alternative 7 would disturb the least habitat.

A conveyor from the Zortman Mine to Goslin Flats would be constructed under Alternatives 4, 6, and 7 that could restrict wildlife access to habitat. Densities of big game species and other wildlife that may be impeded are generally already low in the area of the proposed conveyor. Few bighorn sheep have ever been observed in the area.

Wildlife mortality from mine related traffic would be expected to increase under all expansion alternatives but traffic would not significantly impact wildlife populations. Mortality from process ponds would be negligible for all expansion alternatives as ponds would be netted or covered and fenced.

Sensitive bat species could be negatively impacted by removal and disturbance of riparian areas that provide foraging and breeding habitat. Alternative 5 would disturb riparian habitat in Alder Gulch, whereas Alternatives 4, 6, and 7 would disturb riparian habitat along the conveyor corridor.

Long-term water quality and sedimentation impacts to aquatic macroinvertebrates would be moderate for expansion alternatives 4, 5, and 6, due to the increased disturbance area, moderate reclamation success, coupled with the beneficial effects of water capture and treatment. Long-term water quality and sedimentation impacts to aquatic macroinvertebrates would be least negative under Alternative 7 due to the increase in reclamation success.

Impacts to raptors, special status species, and sensitive wildlife species other than bats would be negligible under all of the expansion alternatives. Noise impacts to wildlife would also be negligible.

Air Quality

Air quality impacts were assessed for each alternative by comparing modeled impacts of air pollutants resulting from mining activities with National Ambient Air Quality Standards, enforceable standards under Montana and federal regulations. The impacts are compared to the Average 24-Hour (150 ug/m^3) and Average Annual (50 ug/m^3) standards for respirable particulate matter, the pollutant of most concern from the mines. Table ES-7 summarizes the estimated PM_{10} concentrations for each alternative.

The most significant factor in air quality impacts to the towns of Zortman and Landusky (the two sensitive receptor locations modeled in the analysis) is truck traffic. The greater the number of truck trips traveling through town per day the higher the atmospheric emissions of particulate matter. None of the alternatives would result in significant impacts to the town of Landusky.

Alternative 3 would cause the greatest level of particulate emission of the non-expansion alternatives because of the more stringent mitigated reclamation requirements than Alternatives 1 or 2. However, significant impacts to air quality would not occur under any of the non-expansion alternatives, since air quality standards would not be exceeded.

Alternative 5 would cause the greatest level of air emissions of the expansion alternatives. No facilities would be located at Goslin Flats and all reclamation material haul trucks would have to drive through the town of Zortman to reach mine disturbances. Alternative 5 would result in significant air impacts since the 24-hour emissions would exceed standard. All of the expansion alternatives would exceed standard if the Pony Gulch ore deposit were developed (a reasonably foreseeable future activity). Alternative 7 has incorporated mitigation to preclude the mining of the Pony Gulch deposit concurrent with Zortman Mine reclamation activities.

Recreation and Land Use

Mining activities have generally resulted in: 1) a loss of access to dispersed use areas that were previously accessed by the Zortman/Landusky county road over Antoine Butte; 2) a reduction in the aesthetic quality of surrounding recreational use areas due to an increase in the amount of visible land disturbances; and 3) a reduction in the quality of recreational experience as a result of noise from mining and reclamation activities.

Under the non-expansion alternatives, access to lands currently within the mine operational areas would continue to be restricted until reclamation activities are complete. Alternative 1 would return lands to other potential uses sooner than Alternative 2, while Alternative 3 would take the longest because of more stringent reclamation requirements. However, Alternative 3 would have the most potential of the three non-expansion alternatives of returning lands to

TABLE ES-7
SUMMARY OF 24-HOUR AND ANNUAL PM_{10} IMPACTS ($\mu g/m^3$) AT SENSITIVE RECEPTOR LOCATIONS

	Alt. 1		Alt. 2		Alt. 3		Alt. 4		Alt. 5		Alt 6		Alt. 7[6]	
	24-hr	Annual	24-hr	Annual	24-hr	Annual	24-hr	Annual	24-hr	Annual	24-hr	Annual	24-hr	Annual
PM_{10} Standard	**150**	**50**	**150**	**50**	**150**	**50**	**150**	**50**	**150**	**50**	**150**	**50**	**150**	**50**
Zortman[2]														
Mining	n/a	n/a	n/a	n/a	n/a	n/a	76	4	**158**	6	59	5	118	5
Reclamation	32	8	57	14	100	4	n/a[3]	n/a[3]	n/a[3]	n/a[3]	n/a[3]	n/a[3]	n/a[3]	n/a[3]
RFD[4]	0	0	0	0	0	0	**189**	48	0	0	**189**	48	**189**	48
Background	30	9	30	9	30	9	30	9	30	9	30	9	30	9
Cumulative[5]	62	17	87	23	130	13	**295**	**61**	**188**	15	**278**	**62**	**148[6]**	**14[6]**
Landusky[2]														
Mining	85	1	85	1	85	1	85	1	85	1	85	1	85	1
Reclamation	14	4	25	6	31	8	31	8	32	8	32	8	32	8
RFD[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Background	30	9	30	9	30	9	30	9	30	9	30	9	30	9
Cumulative[5]	129	14	140	16	146	18	146	18	147	18	147	18	147	18

n/a - not applicable.

1 Concentrations shown are for the maximum impact from any facility modeled. Concentrations above standards are highlighted in **bold**.
2 Concentrations shown are estimated for the applicable townsite, Zortman or Landusky.
3 Reclamation estimates for Zortman Mine expansion alternatives are incorporated in the values presented for mining.
4 RFD = Reasonably Foreseeable Development Activity (for example, Pony Gulch Mine development)
5 Values shown are the summation of mining, reclamation, and background concentrations.
6 Alternative 7 precludes mining of the Pony Gulch deposit concurrent with mining and reclamation at the Zortman Mine. This mitigation prevents exceedance of the air quality standards which would otherwise occur.

productive uses in the long-term. To access reclamation materials Alternative 3 would result in the disturbance of over 300 acres of currently undisturbed lands, while the other two non-expansion alternatives would result in virtually no new land disturbance.

All of the expansion alternatives would cause new disturbance. Alternatives 4, 5, and 6 would result in over 900 acres of combined new disturbance from the two mines, while Alternative 7 would result in about 772 acres of new disturbance. Alternative 5 would cause the most disturbance to public lands (about 535 acres) while Alternative 7 would result in the least disturbance to public lands (about 82 acres). The disturbances resulting from the expansion alternatives are shown on Figure ES-4.

None of the expansion alternatives would result in direct impacts to recreational facilities. The overland conveyor in Alternatives 4, 6, and 7 would restrict access to Goslin Gulch, which is occasionally used by recreationists and biologists to access Saddle Butte and Azure Cave. Hunters could also encounter access restrictions from the conveyor.

Indirect effects from all of the expansion alternatives would be significant, primarily due to the increase in visual, noise, and traffic impacts. Recreationists and sightseers would be exposed to alterations in the natural landscape from mine facilities, such as the leach pad on Goslin Flats. For users requiring scenic quality and natural appearing landscapes, impacts would be significant.

Land use would change in some areas, depending on the amounts of disturbance and disturbance location. In particular, grazing land on Goslin Flats (Alternatives 4, 6, and 7) and Ruby Flats (Alternative 6) would be lost to mining.

Visual Resources

The assessment of visual impacts was based upon impact significance criteria and methodology developed in the BLM's visual contrast rating system. The degree to which project facilities would impact the scenic qualities of the landscape depends on the amount of visible contrast created by project facilities in relation to the existing landscape character. Sensitive viewpoints within the study area, termed Key Observation Points (KOPs), were selected as representative views from travel routes, recreational areas, residential areas, and views from several sites of significance to Native Americans. A total of 21 KOPs were mapped within the study area. These KOPs and mine facilities and disturbances seen from each perspective are listed on Table ES-8.

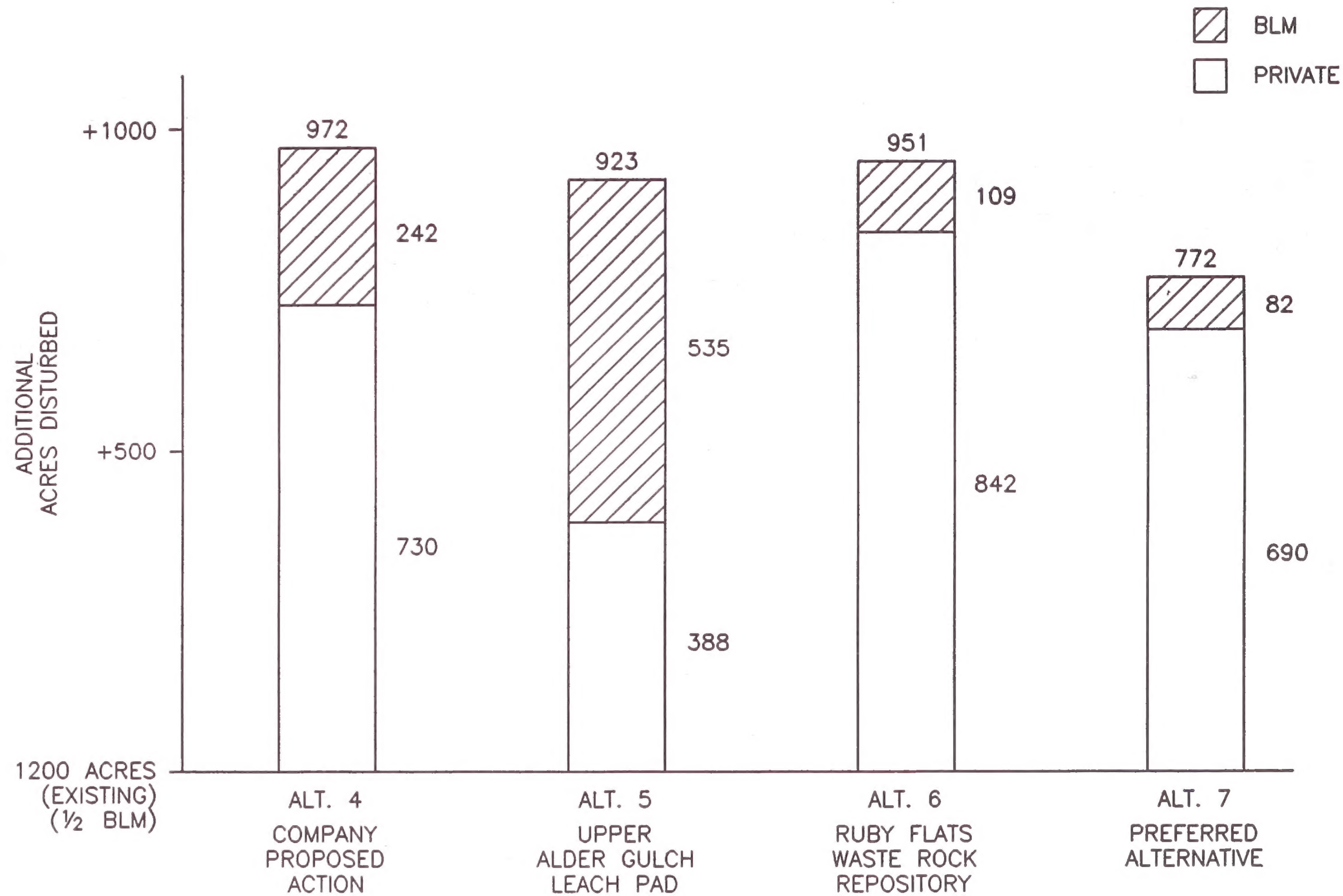
In addition, photographic simulations of the proposed action and alternative facilities were prepared from selected viewpoints. Simulations are from viewpoints with representative views from recreation areas, travel routes and areas traditionally used by Native Americans, and display the existing view and views with the proposed and/or alternative project facilities. Simulations were presented in Appendix D of the Draft EIS (1995).

Open pit mining has caused major changes in landforms, creating sharp contrasts in the line, form, color and textures visible in the landscape. Areas where rock and soil have been exposed contrast with color and texture of the surrounding natural vegetation. Unnatural looking landforms have been created by the excavation of the mine pits, and by the large heap leach pads and waste rock dumps. Roads, especially the downhill sidecast along the roads, create color and line contrasts visible for miles from the mine sites. Benches along the highwall create strong geometric lines and forms that contrast with the characteristic lines and shapes naturally occurring mountain landscapes. The scale of the disturbance dominates the viewers attention. The current disturbance at both the Zortman and Landusky mines is not compatible with the scenery management objectives of VRM Class II landscapes.

Visual impacts from all alternatives would continue to be significant as a result of the topographic alterations cause by mine pits and the large man-made landforms. These would be apparent, even after reclamation.

Visual impacts from the seven alternatives are most appropriately compared between non-expansion alternatives (1 through 3) and expansion alternatives (4 through 7). With both expansion and non-expansion alternatives, successful reclamation would reduce visual contrast. However, reclamation measures for Alternatives 1 and 2 would not be successful and the existing visual contrasts would continue in the long-term. Alternative 3 would also further reduce visual contrasts by removing some existing landforms (such as the Alder Gulch and OK waste rock dumps). These would be used as pit backfill, lessening the visual impact of the pits.

Visual impacts resulting from all of the expansion alternatives would be significant, resulting from the large increases in disturbances and the placement of new facilities in previously undisturbed areas. New facilities at Goslin Flats (Alternatives 4, 6, and 7) and Ruby Flats (Alternative 6) would cause major new disturbances in the landscape and significant visual contrast. Successful reclamation would not reduce the magnitude of these



MINE EXPANSION ALTERNATIVES
ADDITIONAL DISTURBANCE
BY OWNERSHIP

FIG. ES-4

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TABLE ES-8
KEY OBSERVATION POINTS

KOP No.[1]	Viewpoint	Jurisdiction[2]	Elevation (Feet)	View Distance (Miles)		Major Proposed and Alternative Project Facilities Seen[3]									
						Zortman							Landusky		
				Zortman Mine	Landusky Mine	Mine Pit Expansion	Carter Gulch Waste Rock Repository	Overland Conveyor	Goslin Flats Heap Leach	Limestone Quarry	Ruby Terrace Waste Rock Repository	Alder Gulch Heap Leach	Mine Pit Expansion	Heap Leach Pad Extension	Limestone Quarry King Creek
1	CMR-Auto Tour Route	USFW	2,953	17.6	16.3	N	N	N	N	N	N	N	Y	Y	N
2	DY Junction	BLM	3,220	10	8.4	N	N	N	N	N	N	N	Y	Y	N
3	U.S. Hwy. 191 ~3 mi. N of DY Junction	Private	3,120	8.4	7.4	N	N	N	N	N	N	N	Y	Y	N
4	U.S. Hwy. 191-Junction with Dry Fork Rd.	Private	3,220	8.1	8.3	N	N	N	Y	N	Y	N	N	N	N
5	U.S. Hwy. 191 ~3 mi. N of Dry Fork Rd.	State	3,380	8	8.9	Y	Y	N	Y	N	Y	N	N	N	N
6	Bear Gulch Road Junction w/U.S. Hwy. 191	FBIR	3,040	9.3	11.6	Y	N	N	N	N	N	N	N	N	N
7	Bear Gulch Road Landing Strip	Private	3,960	3	3.9	Y	N	Y	Y	N	Y	Y	N	N	N
8	7-Mile Road ~4 mi. N of U.S. Hwy. 191	Private	3,530	5.9	6.4	N	N	Y	Y	N	Y	N	N	N	N
9	State Hwy. 66-Junction w/Landusky Rd.	Private	3,500	6.7	4.5	N	N	N	N	N	N	N	Y	Y	N
10	State Hwy. 66 ~3.5 mi. N of Landusky Rd.	Private	3,880	5.9	3.2	N	N	N	N	N	N	N	Y	N	N
11	State Hwy. 66-Junction w/Lodge Pole Rd.	FBIR	3,280	10	9.5	N	N	N	N	N	N	N	Y	Y	N
12	Lodge Pole	FBIR	3,460	6.8	8.7	Y	N	N	N	N	N	N	N	N	N
13	Pow Wow Grounds-Mission Canyon	FBIR	4,040	3.5	2.1	N	N	N	N	N	N	N	N	Y	N

TABLE ES-8 - KEY OBSERVATION POINTS
(Concluded)

KOP No.[1]	Viewpoint	Jurisdiction[2]	Elevation (Feet)	View Distance (Miles)		Major Proposed and Alternative Project Facilities Seen[3]									
						Zortman							Landusky		
				Zortman Mine	Landusky Mine	Mine Pit Expansion	Carter Gulch Waste Rock Repository	Overland Conveyor	Goslin Flats Heap Leach	Limestone Quarry	Ruby Terrace Waste Rock Repository	Alder Gulch Heap Leach	Mine Pit Expansion	Heap Leach Pad Extension	Limestone Quarry King Creek
14	Landusky townsite	Private	4,000	3.6	1.1	N	N	N	N	N	N	N	Y	N	N
15	Eagle Child Mountain	FBIR	5,243	5.7	3.5	N	N	N	N	N	N	N	Y	N	N
16	Mission Peak	FBIR/BLM	5,480	3	3	N	N	N	N	N	N	N	Y	Y	Y
17	Saddle Butte	BLM	5,192	2.9	3.7	Y	Y	Y	Y	N	Y	N	N	N	N
18	Old Scraggy Peak	BLM	5,708	1.6	4.6	Y	Y	N	Y	Y	N	Y	N	N	N
19	Beaver Mountain	BLM	5,542	2.4	5	Y	N	N	N	Y	Y	N	N	N	N
20	Ricker Butte	FBIR/ Private	3,977	8.6	10.5	Y	Y	Y	Y	N	Y	Y	N	N	N
21	Thornhill Butte	BLM	4,636	7.6	5.1	N	N	N	N	N	N	N	Y	Y	N

1 KOP number corresponds to numbers shown on Figure 4-8.
2 USFW = United States Fish and Wildlife Service
BLM = Bureau of Land Management
FBIR = Fort Belknap Indian Reservation
3 Y = seen; N = not seen; - = no data

impacts below significance. Alternative 7 would require that new facilities such as the Goslin Flats leach pad incorporate natural landscaping and recontouring to attempt to blend the facility into the surrounding landscape. However, even this mitigation would still not reduce impact magnitude below significance, although Class II VRM objectives may be met from more distant viewpoints. Alternative 5 would establish the new Zortman Mine heap leach pad and waste rock repository as valley fill structures near the mine; visual impacts for this alternative would therefore be less significant than for the other expansion alternatives.

The expansion of the Zortman pit complex would cause significant topographic and visual impacts at the mine site. Partial backfilling of the pits at both mines and successful reclamation would only partially offset these impacts. Other mine facilities and features such as new roads, pipelines, conveyors, and transmission lines would increase visual impact. These effects would be short-term, lasting for the duration of mining.

Noise

Noise impacts were assessed for each alternative by comparing expected noise levels from mining activities with guidelines designed to protect against the interference of the public's outdoor activities. The guidance level selected is 55 A-weighted decibels, shortened to "dBA." The dBA reflects a noise rating system which is adjusted to the human ear. Sensitive receptors considered in this analysis are the people in the towns of Zortman and Landusky, and the Pow Wow Grounds, and Azure Cave.

The estimated impacts have been rated as low, moderate, or high magnitude using the EPA noise guideline for outdoor activity as the rating criterion. Low noise impacts are those that are below 53 dBA. Moderate noise impacts were assigned to alternatives in which noise levels were estimated to be in the range of 53 to 57 dBA, and high noise impacts were assigned to alternatives in which substantial exceedances of the EPA guideline were estimated (above 57 dBA). Impacts are considered to be significant if the levels estimated at the receptor locations would interfere with outdoor activity, since outdoor recreation is a common activity of residents and visitors in the Little Rocky Mountains.

The frequency and duration of impacts are also evaluated. Noise caused by certain mining activities such as drilling or blasting could be of a short-term duration, in that the noise would occur for short, possibly intense periods then cease. Or, the impacts could be of long-term duration, such as the noise from reclamation which would extend after mine closure. The frequency of noise also varies. In particular, noise from most mining and reclamation activities would be constant. The loud noise resulting from blasting would be of very short duration and occur infrequently. The noise resulting from haul trucks passing through Zortman and Landusky would occur on a frequent, but short-duration basis. A conservative assumption for all alternatives is that combined noise from mining activities is continuous, and would occur until mine closure. Noise levels at the mines and receptor locations would only return to baseline conditions after mine operations, reclamation, and remediation is complete.

Table ES-9 summarizes the estimated noise levels for each of the alternatives. When added to background noise levels, all of the non-expansion alternatives would result in significant impacts at the Pow Wow Grounds, and Landusky and Zortman. Alternative 3 would also cause significant noise levels at Azure Cave because of mining reclamation materials at Goslin Flats. The frequency and duration of noise impacts would be greatest from Alternative 3, due to the higher number of truck traffic days through the town of Zortman, and because reclamation would take longer than for Alternatives 1 or 2.

Cumulative noise levels resulting from the expansion alternatives would result in significant impacts at all receptor locations, except for Alternative 5 impacts at Azure Cave. These would only be moderate (not significant) since new Zortman Mine facilities would be located near the mine area, and not on Goslin Flats. Impacts to the Pow Wow Grounds and the town of Landusky are generally the same for all expansion alternatives. Impacts to the town of Zortman and Azure Cave would be highest from Alternatives 4 and 6. Alternative 7 would cause lesser (but still significant) impacts at these locations because the Pony Gulch reasonably foreseeable development would not take place concurrent with mining.

Alternative 7 would have no truck traffic passing through the town of Landusky and no resultant short-term noise impacts since clay would not be used in reclamation covers. However, Alternative 7 would cause more frequent noise disturbance from trucks at the town of Zortman than for any of the other expansion alternatives.

TABLE ES-9
SUMMARY OF NOISE LEVELS AT SENSITIVE RECEPTORS FOR EACH ALTERNATIVE[1,2]

Receptor	Alt. 1	Alt. 2	Alt 3.	Alt. 4	Alt. 5	Alt. 6	Alt. 7[4]
Mining							
Pow Wow Grounds	57	57	57	59	59	59	59
Town of Landusky	61	61	61	61	61	61	61
Town of Zortman[3]	54	54	60	63	59	64	63
Azure Cave[3]	54	54	58	59	56	60	59
Cumulative							
Pow Wow Grounds	58	58	58	59	59	59	59
Town of Landusky	62	62	62	63	62	63	63
Town of Zortman	59	59	62	66	60	67	64
Azure Cave	55	55	59	66	57	66	60
Frequency of Truck Traffic at 98 dBA[5]							
Town of Landusky	12 days	27 days	none	27 days	27 days	27 days	none
Town of Zortman	none	12 days	53 days	17 days	26 days	14 days	40 days

1 All noise levels presented in A-weighted decibels, or dBAs. See text for assumptions and explanation.
2 Noise estimates do not account for attenuation from intervening terrain, which would reduce levels, or for atmospheric conditions which could result in higher noise levels downwind from the source.
3 For alternatives 3, 4, 6, and 7, includes noise from activities at Goslin Flats. For Alternative 6, also includes noise from Ruby Flats
4 Cumulative noise levels for Alternative 7 do not include a contribution from the Pony Gulch reasonably foreseeable development, as mining of that deposit would be precluded while mining and reclamation takes place at the Zortman Mine.
5 Estimate based on number of trucks in peak traffic year, divided by 10 convoys of 15 trucks per day, except that Alternative 7 would be limited to no more than 120 trucks per day.

Socioeconomics

The key difference in socioeconomic impact between the non-expansion alternatives (Alternatives 1 - 3) and the expansion alternatives (Alternatives 4 - 7) is the timing of the end of mineral development activity, and therefore the timing of impacts upon the social and economic environment. The end of mineral development activity occurs almost immediately under Alternatives 1 through 3 and is delayed for 5 to 7 years under Alternatives 4 through 7. Despite the difference in timing, it should be emphasized that the impacts that would occur as a result of the end of mineral development would be similar and would inevitably occur under all alternatives, even though these impacts would be delayed for a number of years under the expansion alternatives.

Under the non-expansion alternatives, Alternatives 1 through 3, mining would cease in the near future. Differences among the non-expansion alternatives in terms of projected employment, payroll, business purchases, and taxes reflect differing activities due to the modification of reclamation procedures proposed by ZMI under Alternative 2 and the mitigated reclamation procedures proposed under Alternative 3. ZMI's total tax liability is estimated to be virtually the same under the three non-expansion alternatives because they are similar in terms of capital spending and the outputs of gold and silver. These outputs are the economic characteristics which drive ZMI's liabilities for property taxes and the gross proceeds and metal mines license taxes.

The expansion alternatives, Alternatives 4 through 7, would permit continued mineral development activity and the construction of expanded or new facilities at the Zortman and Landusky mines. Differences among the expansion alternatives in terms of projected employment, payroll, business purchases, and taxes reflect the various locations and configurations of heap leaching and ore and waste rock handling facilities, as well as differing methods and intensities of reclamation activity. The timing of additional construction, mining, and reclamation is similar among the expansion alternatives although Alternative 6 lasts a year less overall compared to Alternatives 4, 5, and 7. Differences in the timing of additional construction, mining, and reclamation also account for the differences in how employment levels begin to decline as the transition is made from mineral development activity to the activities of the closure cycle. This effect is most noticeable in Alternatives 5 and 6, where employment levels for the year 2004 are substantially lower than the employment levels projected for Alternatives 4 and 7 for the same year. ZMI's tax liability would differ somewhat among the expansion alternatives, mainly because of varying levels of capital expenditure and productivity. In general, however, differences among Alternatives 4 through 7 fall within a relatively narrow range.

Figures ES-5 and ES-6 illustrate the similarities and differences across all seven alternatives in graphical terms by plotting employment and spending from 1996 to 2012, the time horizon encompassed by this assessment. The employment levels plotted in the figure represent direct ZMI employment. The spending levels represent the sum of operating and capital expenditures, plus expenditures for contracting, all expressed in 1994 dollars.

Transportation

The assessment of transportation related impacts associated with the alternatives focuses primarily on, 1) the effects of vehicle traffic on local roads and highways, and concerns regarding accident potential and safety of local residents, and 2) transportation of hazardous materials to and from the mines, and risks associated with potential accidents and spills.

Figure ES-7 charts the number of total truck trips associated with the seven alternatives. The majority of trips associated with mine activities result from hauling reclamation materials. For this reason, Alternative 3 would have the greatest number of truck trips in the short-term, much more than the other non-expansion alternatives. Truck trips are much less for Alternative 2, and relatively few trips would be made under Alternative 1, reflecting the lack of reclamation material import. Large numbers of truck trips would occur for about one year longer under Alternative 3 than for the other non-expansion alternatives, until the end of most active reclamation work.

Truck traffic among the expansion alternatives is more variable but the general trends are similar. An initial period of heavy truck traffic would occur, followed by some decrease in activity before a gradual increase in truck trips over the span of several years. Truck trips would begin to decline as Landusky Mine reclamation is completed, and most traffic would have ended by the years 2007 or 2008. Alternative 4 would result in the greatest number of reclamation truck trips over the life of the mine, about 40,000. The other expansion alternatives would have fewer than 35,000 truck trips during mine life.

There is no real difference in the numbers of trucks hauling hazardous materials among the non-expansion alternatives, and among the expansion alternatives. Alternative 3 would result in about 8,050 hazardous

Fig. ES-5. Direct ZMI Employment

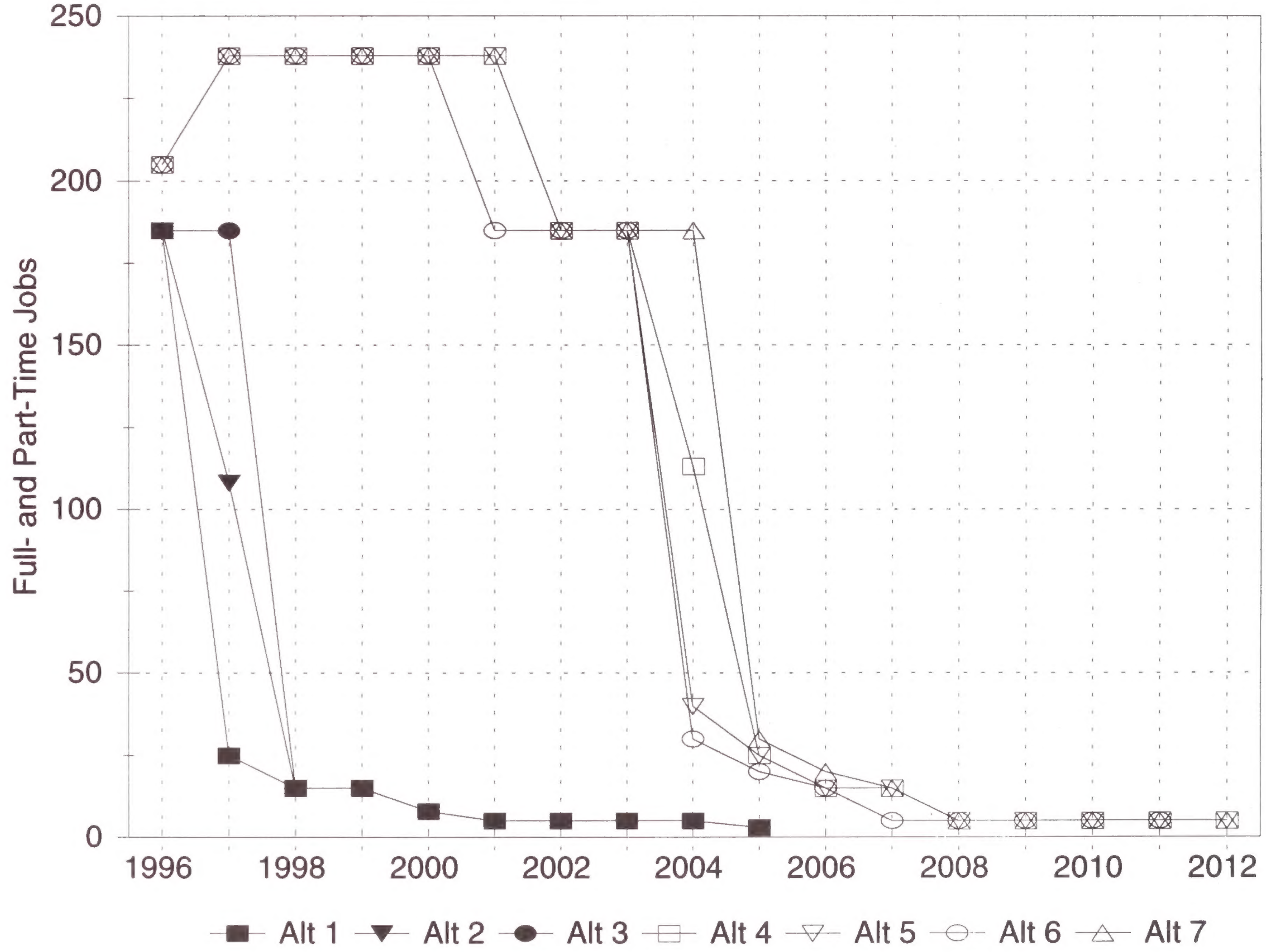

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Fig. ES-6. Total Expenditures by ZMI (in $1994 millions)

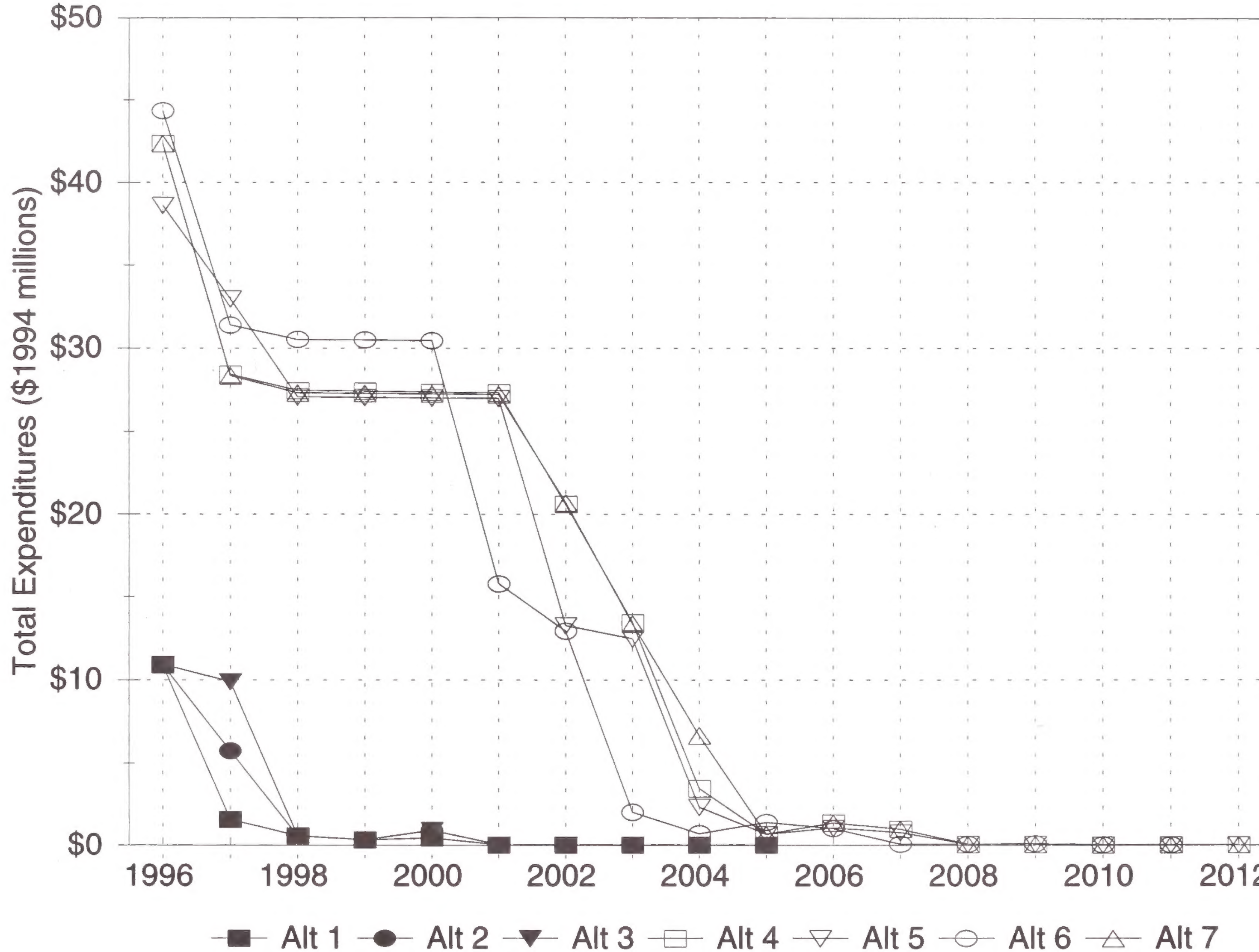

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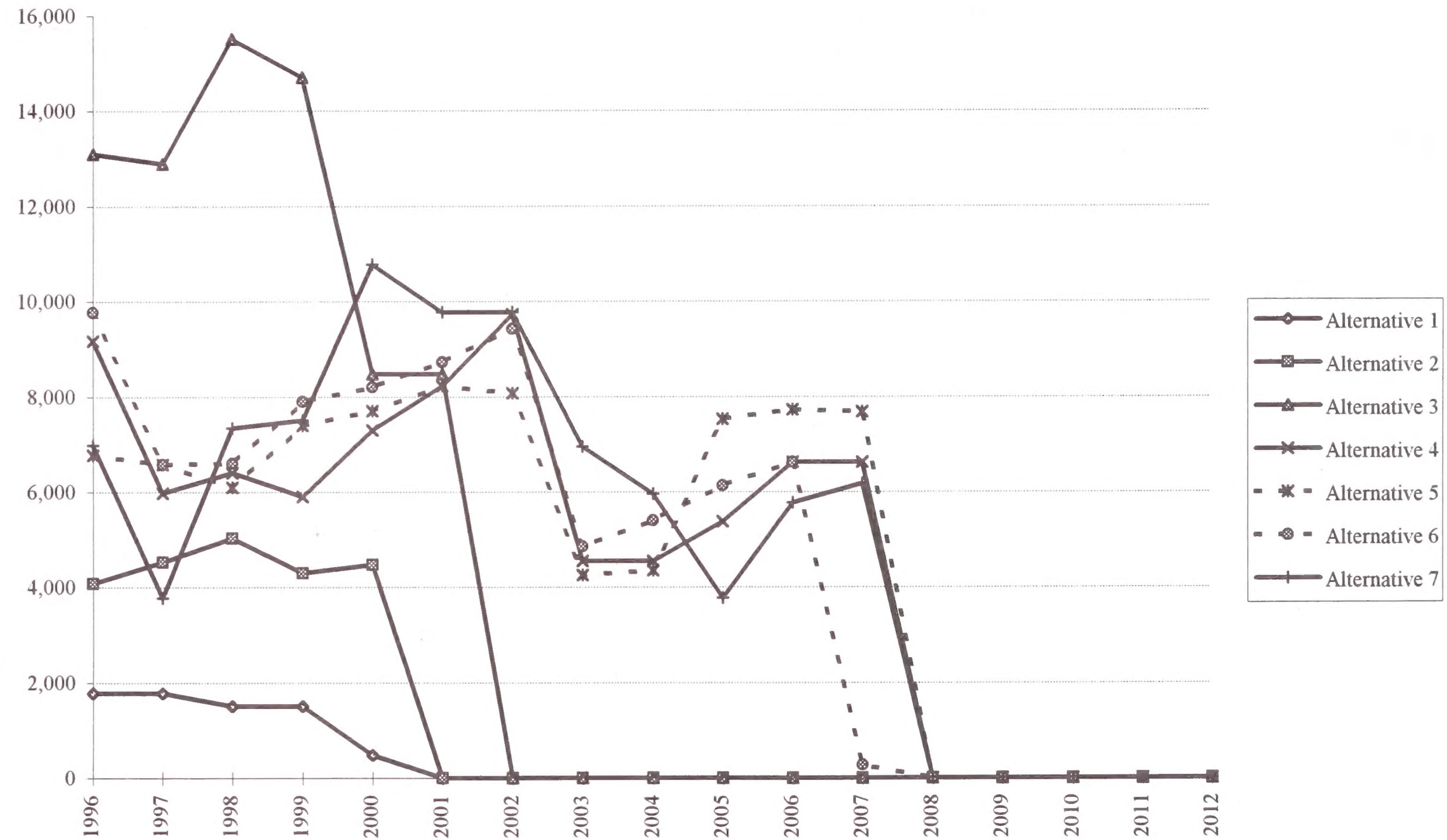
Figure ES-7. Total Annual Truck Trips



materials related trips over the course of mine reclamation, approximately 750 more than Alternative 2 and 1,025 more than Alternative 1. Hazardous materials trips resulting from expansion alternatives are all between 28,500 and 30,000 for the extent of mine life.

What is important and different among some alternatives is the destination for trucks carrying hazardous materials. This does not vary for trucks going to the Landusky Mine, but it is important for trucks associated with the Zortman Mine. Hazardous materials used in ore processing would be transported to Goslin Flats under Alternatives 4, 6, and 7, while the same materials would be transported to the mine site under Alternative 5. The risks associated with this activity would be greater under Alternative 5 because the materials would be transported a greater overall distance, and they would pass through the town of Zortman.

Cultural Resources

Existing impacts to cultural resources are displayed in Table ES-10. The purpose of this tabulation is to show existing impacts to the sample of 41 Native American sites identified from literature and other sources for the period of surface mining, from 1979 to 1995. These sites are all within the working boundaries of the Traditional Cultural Property (TCP) Historic District. Impacts from previous periods of mining within the Zortman and Landusky project areas were existent prior to 1979 and carry over into the present period. Table ES-10 shows that the existing impacts for physical, visual, and aural impacts associated with the Zortman Mine site are all high. Similarly, the existing impacts for physical, visual, and aural impacts associated with the Landusky Mine site are all high.

The impacts to these sites are all negative and represent the existing condition, or threshold, for the assessment of each of the expansion and non-expansion alternatives. Other considerations, such as the effects of the alternative mining plans on the larger TCP District and associated Native American values, are also factored into the assessment, albeit in a less quantitative manner.

In assessing the various alternatives, the effects of existing impacts must be taken into account. Significant physical disturbance from historic mining has occurred in Montana Gulch, Beaver Creek, and Pony Gulch. Mill tailing had been deposited in King Creek, Alder Gulch, and Ruby Gulch. Since 1979, there has been additional disturbance to these areas and extensive new physical disturbance associated with Antoine Butte and Shell Butte (Zortman), and Gold Bug Butte and Mission Peak (Landusky). As shown in Table ES-10, existing visual and aural impacts are also significant, ranging from neutral to high, depending upon visibility and distance from mining activities.

Impacts to Native American cultural resources include impacts to the National Register eligible TCP Historic District, individual cultural properties identified within the District, and the associated traditional Native American values. As long as the mines continue to operate, these impacts remain a significant and serious issue for Native American traditionalists. This conclusion follows from the literature review (see Section 3.12.3 of the Final EIS); and the comments from Native Americans presented at the many public meetings held concerning the Zortman and Landusky mines. Additionally, this conclusion is supported by Programmatic Agreement consultation meetings and public comment received during review of the Draft EIS. All of this information supports the perception to traditionalists that more sites and areas would be rendered unavailable, unacceptable, or less desirable with the continuation of mining in the Little Rocky Mountains, and that no mitigation could make these impacts acceptable.

All the alternatives represent relatively high and negative impacts to cultural resources. Relative to each other, however, some alternatives would create a greater impact. The following table shows these relative rankings based on impacts to prehistoric, historic, and traditional cultural properties.

Relative Impact Rankings to Cultural Resources

Alternative	Ranking (1 = most favorable)
1	2
2	2
3	1
4	4
5	3
6	4
7	4

Of all the alternatives, Alternative 3 is the most favorable due to no additional mining, and improved reclamation measures. The other two no expansion alternatives are ranked second for their lower intensity reclamation efforts. However, all of the non-expansion

TABLE ES-10
NATIVE AMERICAN CULTURAL RESOURCES: EXISTING IMPACTS

No.	Site Type (Primary)	Site Activity (Primary)	Visibility		Distance		Zortman			Landusky		
			Zortman	Landusky	Zortman	Landusky	P	V	A	P	V	A
01.	Religion & Ritual	Vision Questing	yes	no	2.0	4.0	N	H	H	N	N	M
02.	Religion & Ritual	Vision Questing	no	yes	2.2	0.0	N	N	M	H	H	H
03.	Religion & Ritual	Vision Questing	yes	no	1.0	3.1	N	H	H	N	N	M
04.	Religion & Ritual	Fasting	yes	yes	2.7	1.7	N	H	M	N	H	H
05.	Religion & Ritual	Fasting	no	no	1.5	3.5	N	N	H	N	N	M
06.	Religion & Ritual	Vision Questing	yes	yes	2.2	3.1	N	H	M	N	M	M
07.	Religion & Ritual	Vision Questing	yes	yes	0.4	1.0	N	H	H	N	H	H
08.	Religion & Ritual	Vision Questing	yes	no	0.2	2.2	H	H	H	N	N	M
09.	Religion & Ritual	Vision Questing	yes	no	5.8	7.8	N	M	L	N	N	N
10.	Religion & Ritual	Vision Questing	no	yes	2.8	0.2	N	N	M	H	H	H
11.	Religion & Ritual	Vision Questing	no	yes	5.5	2.8	N	N	L	N	H	M
12.	Religion & Ritual	Fasting	no	yes	4.0	0.7	N	N	M	N	H	H
13.	Religion & Ritual	Vision Questing	yes	yes	4.4	2.7	N	M	L	N	H	M
14.	Religion & Ritual	Vision Questing	yes	no	3.4	5.7	N	M	M	N	N	L
15.	Religion & Ritual	Vision Questing	no	no	7.2	4.4	N	N	N	N	N	L
16.	Religion & Ritual	Vision Questing	no	no	4.0	6.0	N	N	M	N	N	L
17.	Religion & Ritual	Vision Questing	no	yes	7.4	4.0	N	N	N	N	M	M
18.	Religion & Ritual	Vision Questing	yes	no	7.8	9.6	N	L	N	N	N	N
19.	Religion & Ritual	Fasting	no	no	6.4	7.2	N	N	N	N	N	N
20.	Religion & Ritual	Vision Questing	no	yes	6.6	8.4	N	N	N	N	L	N
21.	Religion & Ritual	Offering Area	no	no	3.7	1.4	N	N	M	N	N	H
22.	Religion & Ritual	Fasting	no	yes	2.6	0.6	N	N	M	N	H	H
23.	Religion & Ritual	Vision Questing	yes	yes	3.4	3.3	N	M	M	N	M	M
24.	Religion & Ritual	Vision Questing	yes	no	3.9	3.8	N	M	M	N	N	M
25.	Religion & Ritual	Vision Questing	yes	no	1.2	3.0	N	H	H	N	N	M
26.	Rock Art	Prehistoric Site	no	no	2.3	2.6	N	N	M	N	N	M
27.	Rock Art	Prehistoric Site	no	no	2.4	2.3	N	N	M	N	N	M

TABLE ES-10 - NATIVE AMERICAN CULTURAL RESOURCES: EXISTING IMPACTS (Concluded)

			Visibility		Distance		Zortman			Landusky		
No.	Site Type (Primary)	Site Activity (Primary)	Zortman	Landusky	Zortman	Landusky	P	V	A	P	V	A
28.	Rock Art	Prehistoric Site	no	no	3.2	2.3	N	N	M	N	N	M
29.	Rock Art	Prehistoric Site	no	no	2.3	2.7	N	N	M	N	N	M
30.	Burial	Burial	no	no	7.0	4.2	N	N	N	N	N	L
31.	LRM Burials	Burial	?	?	?	?	U	U	U	U	U	U
32.	Healing	Medicinal Spring	no	no	4.3	2.4	N	N	L	N	N	M
33.	Healing	Healing Waters	no	no	6.3	8.3	N	N	N	N	N	N
34.	Sundance	Sundance Site	no	no	4.3	3.3	N	N	L	N	N	M
35.	Sundance	Sundance Site	no	yes	3.2	1.8	N	N	M	N	H	H
36.	Resource Procurement	Fossil Gathering	no	no	3.4	5.4	N	N	M	N	N	L
37.	LRM Resource Procurement	Plant Gathering	yes	yes	0.0	0.0	H	H	H	H	H	H
38.	Historic Event	Historic Battle Site	no	no	4.9	2.8	N	N	L	N	N	M
39.	Historic Event	Coming Day's Route	?	?	?	?	U	U	U	U	U	U
40.	Pipe Offering	Flat Pipe Offering	no	no	7.0	4.2	N	N	N	N	N	L
41.	Powwow	Pow Wow Grounds	no	no	3.6	1.6	N	N	M	N	N	H
						Impact Score	3.00	2.53	2.03	3.00	2.61	2.12
						Impact Level	High	High	High	High	High	High
										IMPACT TOTALS		
										Zortman		High
										Landusky		High
										Combined Total		High

P = Physical Impact, V = Visual Impact, A = Aural Impact; H = High Impact, M = Moderate Impact, L = Low Impact, N = No Impact, U = Unknown Impact; High = 3, Moderate = 2, Low = 1.

To compute impact scores, the individual impact scores are summed and then divided by the number of individual impacts. Situations of No, Neutral, or Unknown impact are not used in computing impact scores. Low impacts are represented by a score of 0.0 - 1.0, Moderate impacts be a score of 1.0 - 2.0, and High impacts by a score of 2.0 - 3.0.

alternatives would have less impact than the mine expansion alternatives.

Of the mine expansion alternatives, Alternative 5 is most favorable due to lower impacts to historic and prehistoric sites. This is due to the fact that no conveyor system would be built through the Alder Gulch Historic District. Additionally, visual impacts to Saddle Butte would be slightly lower for Alternative 5 with no leach pad on Goslin Flats. However, impacts to Native American cultural resources (the Little Rocky Mountains TCP) would be essentially the same for Alternatives 4, 5, 6, or 7. Though Alternative 7 would disturb approximately 200 fewer acres within the TCP District than other alternatives, it is ranked the same due to its similar impacts to the Alder Gulch historic district. The other three expansion alternatives are all ranked approximately equal due to their anticipated levels of disturbance to prehistoric, historic and traditional cultural properties.

Areas of Critical Environmental Concern

Five areas within or in close proximity of the Little Rocky Mountains have been nominated or designated as ACECs. These areas include Azure Cave and prairie dog towns within the 7km Complex that have been designated ACECs by the BLM. The BLM has received nominations for the following areas: Little Rocky Mountains, Saddle Butte, and Old Scraggy Peak. The following sections summarize potential impacts to each of these existing and nominated ACECs.

Azure Cave: Azure Cave was designated as an ACEC based on its significant vertebrate biology, particularly hibernating bats, and geologic values such as the abundance of speleothems. Past and present mining are not known to have adversely impacted biologic and geologic resources of Azure Cave. No speleothems or limestone formations have been broken, and apparent declines in the number of hibernating bats may be explained by natural fluctuations and nationwide declines in bat populations.

The expansion alternatives would not have direct impacts on the cave or hibernating bats. However, several indirect impacts could occur including noise, mortality from consumption of cyanide solutions, and destruction of riparian foraging areas and drinking water sources. Mitigation for loss of drinking water sources and methods to prevent mortality from cyanide solution ponds are incorporated into the expansion alternatives and effects would not be significant.

The cumulative effects of noise, vibration, and habitat loss, particularly in riparian and mature Douglas fir along Alder, Carter, and Pony Gulches combined with habitat previously lost due to historic and existing mining, could adversely impact summer breeding bats by directly removing breeding and foraging habitat or causing bats to avoid the area (Taylor 1994). Cumulative impacts to Azure Cave resources would be short-term in nature.

Prairie Dog 7km Complex: The Prairie Dog 7km complex is more than 8 miles south of the Little Rocky Mountains, and previous mining activities have not impacted the ACEC. No impacts would occur to the Prairie Dog 7km complex under any alternative because the nearest prairie dog town is approximately 8 miles south of proposed mining activity.

Little Rocky Mountains: Impacts from recent mining (1979 to present) to Native American cultural resources have been significant and include physical, visual, and aural impacts. Previous impacts to ethnographic cultural resources include actual physical removal of parts of sacred places such as Shell Butte (Zortman) and Gold Bug Butte (Landusky).

Cultural resources impacts under all alternatives are relatively high and negative. Relative to each other, however, some alternatives would create a greater impact to cultural resources than others. Relative impacts would be greatest under Alternatives 4, 6, and 7; slightly less under Alternative 5 (primarily due to the lack of the conveyor system and facilities in Goslin Flats); still less under Alternatives 1 and 2; and least under Alternative 3.

Impacts to cultural resources would not change the relevance and importance of the Little Rocky Mountains and, hence, its nomination as an ACEC.

Saddle Butte: There have been no direct impacts to Saddle Butte from mining from 1979 to present. The ACEC nomination is approximately 2 miles south of existing and proposed mining activity under Alternatives 1, 2, 3, and 5. Because of this distance, impacts to vegetation, and hence ACEC nomination, would be negligible. Saddle Butte is located directly west of the proposed Goslin Flats heap leach pad and thus would be most impacted by Alternatives 4, 6 and 7, particularly the diversion ditches around the leach pad; however, the *Pseudotsuga menziesii/Andropogon scoparius* vegetation community would not be directly or indirectly impacted by disturbance. Therefore, impacts to the unique vegetation community that is the basis for ACEC

nomination would be negligible for all alternatives and would not affect potential ACEC designation.

<u>**Old Scraggy Peak**</u>: Impacts from mining 1979 to present on Native American cultural resources, including Old Scraggy Peak, have been significant though limited to visual and aural impacts; no direct disturbance has occurred. Impacts would consist of visual and aural impacts of mining at the Zortman Mine and would be greatest under Alternatives 4 through 7 and least for Alternative 1 through 3. Therefore, impact rankings range from negligible for Alternatives 1-3 to negative moderate for Alternatives 4-7, reflecting the relative cultural resource impact rankings. However, no impacts from any alternative would affect ACEC designation.

Hazardous Materials

A number of regulated and unregulated hazardous materials have been used at the Zortman and Landusky mines from 1979 to the present. Hazardous materials would continue to be used at the two mines under any of the alternatives, but the types and quantities of materials used would depend on whether an expansion or non-expansion alternative is selected. Examples of hazardous materials used include diesel fuel, oil and lubricants for mine vehicles, sodium cyanide for heap leaching of ore, ammonium nitrate for blasting, and various other reagents used for controlling the chemistry of the process solution and extraction of precious metals from the pregnant process solution. The toxic hazard characteristics of these materials vary considerably. The most toxic substances used at the mines include sodium cyanide, hydrochloric acid, and sodium hydroxide, which are extremely hazardous and can cause severe injury or death in small doses.

Potential project impacts that could arise from hazardous materials use at the Zortman and Landusky Mines are associated with, 1) normal or routine uses of hazardous materials and disposal practices, and 2) accidental spills or uncontrolled releases of hazardous materials into the environment.

Normal uses or disposal practices involving hazardous materials that could result in environmental impacts include the use of cyanide solution for heap leaching of ore, which could leave residual contamination (cyanide and other chemical reagents) in the spent ore heaps; disposal of laboratory wastes, fume scrubber runoff, and water treatment plant metal hydroxide sludge on leach pads at the mines; and potential nitrate pollution of water resources due to blasting with ammonium nitrate (a component of ANFO). It is possible that residual metals, cyanide compounds, nitrates, and other chemicals could be released into surface and groundwater resources from leach pad and waste rock dumps. Reclamation of heap leach pads and waste rock dumps would include covers that should reduce the amount of infiltration that would occur, thereby reducing the amount of potentially contaminated leachate generated. The reclamation cover performance is discussed in the summary of impacts to water resources in this document, and Section 4.2 of the EIS. Capture and treatment of leachate/seepage should prevent the release of these materials into the environment.

Another type of waste disposal practice used by the mines is land application disposal (LAD) of neutralized cyanide solution. If LAD is performed improperly, cyanide solution can run off the LAD area and enter adjacent drainages, thereby impacting water quality and possibly wildlife using the contaminated water resource. LAD areas require careful monitoring to ensure that soils are not "overloaded" with metals from the spent solution.

Accidental spills and releases of hazardous materials have occurred in the past at the mines and could occur again in the future under the various project alternatives. Depending on the material spilled and its concentration, these incidents can result in the exceedence of water quality standards and impact wildlife using the water resource.

Potential impacts associated with hazardous material use, storage, and disposal for Alternatives 1, 2, or 3 would be limited to existing facilities and relatively modest hazardous material usage during final leaching and reclamation. The potential for future impacts to the environment from hazardous materials management cannot be predicted with certainty, but reclamation measures including capture and treatment of contaminated leachate coupled with existing spill contingency measures, should greatly reduce the potential for adverse impacts. A low negative impact rating has been assigned for Alternatives 1,2, and 3.

For the mine expansion alternatives (Alternatives 4, 5, 6, and 7), additional mining would result in the use of substantial quantities of hazardous materials over the life of the mine expansions. Although various reclamation measures would be carried out and water capture and treatment may occur as needed to reduce impacts on the environment, the increase in quantities of hazardous materials that would be used, along with the construction of new facilities in new locations (e.g. Goslin Flats leach pad), would increase the potential for hazardous materials related impacts in the project area.

As a result, a moderate negative impact rating has been assigned for all of the expansion alternatives.

Summary of Impacts by Alternative

Table ES-11 is provided as an impact summary matrix. The table contains both quantitative information and/or relative impact rankings for each resource and for primary issues of concern under the resources. The relative impact rankings include high (which is considered a significant level of impact), moderate, low, and negligible. The rankings shown in Table ES-11 are based on professional and technical judgement in view of this particular project, its setting and context, and the effects of this project in both a site-specific and regional sense. More information is available in Chapter 4 of the Final EIS regarding methods and criteria used to assess impacts for each resource.

TABLE ES-11
SUMMARY OF IMPACTS[1]

Resource	ALT. 1		ALT. 2		ALT. 3		ALT. 4		ALT. 5		ALT. 6		ALT. 7	
	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L
WATER RESOURCES														
Surface Water Quality	-High		-High		-Low		-Moderate		-Moderate		-Low		-Low	
Groundwater Quality	-High		-High		-Low		-Moderate		-Moderate		-Low		-Low	
% Infiltration	Flats 23% Slopes 23%		23% 23%		8% 10.5%		0.03% (3:1) 7.8%		0.005% 7.8%		0.005% 7.8%		8% 10.5%	
Volume of Water Requiring Capture and Treatment (gpm average over 20 years)	378-450 gpm		348-419 gpm		211-284 gpm		307-389 gpm		322-423 gpm		244-313 gpm		253-321 gpm	
Overall Cumulative Impact Ranking	-High		-High		-Low to Neutral		-Moderate		-High		-Moderate		-Low	
"Long-Term" Reclamation Success (water quality)	-High		-High		+Moderate		+Low		+Low		+Low		+Moderate	
SOIL RESOURCES														
• Soil Disturbance (cumulative: in acres)	1248		1257		1498		2375		2364		2391		2195	
• Soil Productivity	-High		-High		-Moderate		-Moderate		-Moderate		-Moderate		-Moderate	
• Soil Erosion	-High		-High		-Moderate		-Moderate		-Moderate		-Moderate		-Moderate	
• Total Soil Loss from Major Facilities (tons/acre/year)	3.38		3.38		1.76		1.77		1.63		1.73		1.31	
RECREATION AND LAND USE														
Developed Recreation (campgrounds, picnic areas, Pow Wow grounds)	-Low	-Mod.	-Low	-Mod	-Low	-Low	-Low/ Mod	-Mod	-Low	-Mod	-Mod	-Mod	-Low/ Mod	-Mod
Dispersed Recreation (hiking, sightseeing, ORV, hunting, picnicking)	-Mod	-Mod	-Low/ Mod	-Mod	-Low	-Low	-Mod	-Mod	-Low	-Mod	-High	-Mod	-Mod	-Mod
Land Use	-High	-High	-Mod	-Mod	-Low	-Low	-Mod	-Mod	-Low	-Mod	-High	-Mod	-Mod	-Mod
CULTURAL RESOURCES														
• Overall Impact Level	-Moderate		-Moderate		-Low		-High		-High		-High		-High	
• Relative Ranking (1 = most favorable)	2		2		1		4		3		4		4	

TABLE ES-11 - SUMMARY OF IMPACTS[1]
(Continued)

Resource	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT. 5	ALT. 6	ALT. 7
	Z L	Z L	Z L	Z L	Z L	Z L	Z L
WILDLIFE AND AQUATICS							
• Special Status Species	NI	NI	NI	-Low	-Low	-Low	-Low
• Nesting Raptors	NI	NI	NI	NI	NI	NI	NI
• Habitat Loss (in acres)	1248	1257	1498	2212	2282	2431	2064
• Residual Long-term Water Quality Effects	-Moderate	-Moderate	NI	-Moderate	-Moderate	-Moderate	-Low/NI
• Long-term Sedimentation Effects	-Moderate	-Moderate	-Low	-Moderate	-Moderate	-Moderate	-Low
• Long-term Wildlife Mortality	NI	NI	NI	NI	NI	NI	NI
• Noise Effects	NI	NI	NI	NI	NI	NI	NI
• Long-term Reclamation Effects	-High	-High	NI	-Moderate	-Moderate	-Moderate	NI
VEGETATION, WETLANDS AND OTHER WATERS OF THE U.S.							
• Special Status Species Habitat	NI	NI	NI	NI	NI	NI	NI
• Sole Source of Veg. Used by Native Americans	NI	NI	NI	NI	NI	NI	NI
• Forest Vegetation Impacted (cumulative, in acres disturbed)	1029	1029	1034	1387	1550	1245	1285
• Riparian Vegetation Impacted (cumulative, in acres)	16	16	16	26	43	26	25
• Predicted Revegetation Success, as Percent Vegetative Cover	<80%	<80%	>90%	80-89%	80-89%	80-89%	>90%
• Overall Cumulative Vegetation Impacts	-High	-High	-Low	-Moderate	-Moderate	-Moderate	-Low
• Cumulative Wetland Direct Impacts (in acres)	0.03	0.03	0.03	1.09	0.05	1.09	1.09
• Cumulative Wetland Indirect Impacts (in acres)	---	---	1.54	.48	.24	4.07	.48

TABLE ES-11 - SUMMARY OF IMPACTS[1]
(Continued)

Resource	ALT. 1		ALT. 2		ALT. 3		ALT. 4		ALT. 5		ALT. 6		ALT. 7	
	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L
• Cumulative Non-Wetland Waters Direct Impacts (in acres)	4.21		4.21		4.21		7.87		6.29		7.07		7.37	
• Cumulative Non-Wetland Waters Indirect Impacts (in acres)	16.0		16.0		16.4		23.3		16.4		24.7		23.3	
• Overall Cumulative Wetland Impacts														
Pre-Mitigation	-Low		-Low		-Moderate		-Moderate		-High		-High		-Moderate	
Post-Mitigation	-Low		-Low		-Moderate		-Low		-Moderate/Low		-Moderate/Low		-Low	
• Overall Cumulative Non-Wetland Waters														
Pre-Mitigation	-High		-High		-High		-High		-High		-High		-High	
Post-Mitigation	-High		-High		-Moderate		-Moderate/Low		-Moderate/Low		-Moderate/Low		-Moderate/Low	
SOCIOECONOMICS														
Employment														
• Montana employment (cumulative; in job-years)	561		744		909		5,000		4,821		4,524		5,156	
• Phillips County employment (cumulative; in job-years)	437		571		698		3,480		3,356		3,173		3,608	
• Blaine County employment (cumulative; in job-years)	20		26		32		144		139		133		133	
Earnings														
• Montana earnings (cumulative; in millions of 1994 dollars)	$14.8		$19.5		$23.8		$126.4		$121.8		$114.8		$130.6	
• Phillips County earnings (cumulative; in millions of 1994 dollars)	$12.3		$16.0		$19.6		$95.6		$92.2		$87.4		$99.3	
• Blaine County earnings (cumulative; in millions of 1994 dollars)	$0.4		$0.5		$.06		$2.6		$2.5		$2.4		$2.7	

TABLE ES-11 - SUMMARY OF IMPACTS[1] (Continued)

Resource	ALT. 1		ALT. 2		ALT. 3		ALT. 4		ALT. 5		ALT. 6		ALT. 7	
	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L
Tax Revenues														
• Montana direct tax revenues (cumulative; in millions of 1994 dollars)	$0.44		$0.44		$0.44		$4.46		$4.30		$3.60		$4.29	
• Phillips County tax revenues (cumulative; in millions of 1994 dollars)	$0.25		$0.25		$0.25		$2.63		$2.57		$2.44		$2.61	
• Malta School Districts direct tax revenues (cumulative; millions of 1994 dollars)	$0.12		$0.12		$0.12		$1.25		$1.22		$1.15		$1.24	
• Dodson High School District direct tax revenues (cumulative; in millions of 1994 dollars)	$0.11		$0.11		$0.11		$1.12		$1.10		$1.03		$1.11	
• Landusky School District direct tax revenues (cumulative; in millions of 1994 dollars)	$0.07		$0.07		$0.07		$0.73		$0.72		$0.68		$0.73	
• City of Malta direct tax revenues (cumulative; in 1994 dollars)	Negligible		Negligible		Negligible		<$10,000		<$10,000		<$10,000		$10,000	
• County Hard Rock Trust Reserve district tax revenues (cumulative; in millions of 1994 dollars)	$0.06		$0.06		$0.06		$0.59		$0.57		$0.48		$0.57	
TRANSPORTATION														
• Traffic Capacity	-Low		-Low		-Low		-Low		-Low		-Low		-Low	
• Accidents	-Low		-Low		-Low		-Low		-Low		-Low		-Low	
• Transport of Hazardous Materials	-Low		-Low		-Low		-Low		-Low		-Low		-Low	
• Public Access to Parts of the LRM (duration of impact - until year)	-High (until 2001)		-High (until 2001)		-High (until 2002)		-High (until 2008)		-High (until 2008)		-High (until 2007)		-High (until 2008)	
• Safety in Local Communities	-Low	-Low	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	NI
(# convoyed truck trips thru town per day; duration in peak year)	0	0	300 trip 12 days	300 trip 27 days	300 trip 14 days	300 trip 35 days	300 trip 17 days	300 trip 27 days	300 trip 25 days	300 trip 27 days	300 trip 14 days	300 trip 27 days	240 trip 42 days	0

TABLE ES-11 - SUMMARY OF IMPACTS[1]
(Continued)

Resource	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT. 5	ALT. 6	ALT. 7
	Z L	Z L	Z L	Z L	Z L	Z L	Z L
VISUAL RESOURCES	-High	-High	-High	-High	-High	-High	-High
NOISE[2] (in dBA; all impacts negative)							
• Cumulative Mine Noise Impacts, Town of Zortman	59 dBA High	59 dBA High	62 dBA High	66 dBA High	60 dBA High	67 dBA High	64 dBA High
• Cumulative Mine Noise Impacts, Town of Landusky	62 dBA High	62 dBA High	62 dBA High	63 dBA High	62 dBA High	63 dBA High	63 dBA High
• Cumulative Mine Noise Impacts, Pow Wow Grounds	58 dBA High	58 dBA High	58 dBA High	59 dBA High	59 dBA High	59 dBA High	59 dBA High
• Cumulative Mine Noise Impacts, Azure Cave	55 dBA Moderate	55 dBA Moderate	59 dBA High	66 dBA High	57 dBA Moderate	66 dBA High	60 dBA High
AIR[3] (in $\mu g/m^3$)							
• 24-hour and Annual PM_{10} Mining and Reclamation Impacts, Estimated at Town of Zortman	32 $\mu g/m^3$ NI 8 $\mu g/m^3$ NI	57 $\mu g/m^3$ Low 14 $\mu g/m^3$ NI	100 $\mu g/m^3$ Mod 4 $\mu g/m^3$ NI	76 $\mu g/m^3$ Low 4 $\mu g/m^3$ NI	158 $\mu g/m^3$ High 6 $\mu g/m^3$ NI	59 $\mu g/m^3$ Low 5 $\mu g/m^3$ NI	118 $\mu g/m^3$ Mod 5 $\mu g/m^3$ NI
• Cumulative 24-Hour PM_{10} Impacts, Estimated at Town of Zortman	62 $\mu g/m^3$ Low	87 $\mu g/m^3$ Low	130 $\mu g/m^3$ Mod	295 $\mu g/m^3$ High	188 $\mu g/m^3$ High	278 $\mu g/m^3$ High	148 $\mu g/m^3$ Mod
• 24-hour and Annual PM_{10} Mining and Reclamation Impacts, Estimated at Landusky Mine	85 $\mu g/m^3$ Mod 14 $\mu g/m^3$ NI	85 $\mu g/m^3$ Mod 25 $\mu g/m^3$ Low	85 $\mu g/m^3$ Mod 31 $\mu g/m^3$ Low	85 $\mu g/m^3$ Mod 31 $\mu g/m^3$ Low	85 $\mu g/m^3$ Mod 32 $\mu g/m^3$ Low	85 $\mu g/m^3$ Mod 32 $\mu g/m^3$ Low	85 $\mu g/m^3$ Mod 32 $\mu g/m^3$ Low
• Cumulative 24-Hour PM_{10} Impacts, Estimated at Town of Landusky	129 $\mu g/m^3$ Mod	140 $\mu g/m^3$ Mod	146 $\mu g/m^3$ Mod	146 $\mu g/m^3$ Mod	147 $\mu g/m^3$ Mod	147 $\mu g/m^3$ Mod	147 $\mu g/m^3$ Mod
HAZARDOUS MATERIALS	-Low	-Low	-Low	-Moderate	-Moderate	-Moderate	-Moderate

TABLE ES-11 - SUMMARY OF IMPACTS[1] (Concluded)

Resource	ALT. 1		ALT. 2		ALT. 3		ALT. 4		ALT. 5		ALT. 6		ALT. 7	
	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L
GEOLOGY														
• Disturbance for Construction and Reclamation Materials (in acres)	0	0	3	6	65	0	23	10	25.5	12	25	12	17	3
• Cumulative Disturbance for Construction and Reclamation (in acres)	4.2	29	7.2	35	69.2	29	27.2	39	29.7	41	29.2	41	21.2	32
• Anticipated Gold Production (in Troy ounces)	0 oz.		0 oz.		0 oz.		960,000 oz.		960,000 oz.		804,000 oz.		960,000 oz.	
• Anticipated cumulative Gold Production plus Reasonably Foreseeable (in Troy ounces)	1.4 million oz.		1.4 million oz.		1.4 million oz.		2.64 million oz.		2.6 million oz.		2.48 million oz.		2.64 million oz	
ACECs (Areas of Critical Environmental Concern)														
• Azure Cave (and associated bat habitat)	NI		NI		NI		Low		NI		Low		Low	
• Prairie Dog Towns	NI		NI		NI		NI		NI		NI		NI	
• Little Rocky Mountains (proposed)	NI		NI		NI		-Moderate		-Low		-Moderate		-Moderate	
• Saddle Butte (proposed)	NI		NI		NI		NI		NI		NI		NI	
• Old Scraggy Peak (proposed)	NI		NI		NI		-Moderate		-Moderate		-Moderate		-Moderate	

Notes:
[1] Where applicable, impacts are differentiated by Zortman Mine (Z) and Landusky Mine (L)
[2] Significance threshold is 55 dBA, the estimated level above which noise would interfere with outdoor activity.
[3] Significance thresholds are the 24-Hour, PM_{10} standard of 50 $\mu g/m^3$; and the Annual PM_{10} standard of 150 $\mu g/m^3$.

Key:
- = Negative impact
+ = Positive impact

High = High level of impact (significant)
Mod/Moderate = Moderate level of impact
Low = Low level of impact
NI = Negligible impact

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ABA	Acid-Base Accounting
ACEC	Area of Critical Environmental Concern
ACHP	Advisory Council on Historic Preservation
ACO	Administrative Compliance Order
ADT	Average Daily Traffic
AGP	Acid-Generating Potential
AIRFA	American Indian Religious Freedom Act
AMD	Acid Mine Drainage
ANB	Average Number Belonging
ANFO	Ammonium Nitrate and Fuel Oil
ANP	Acid Neutralizing Potential
AP	Acid Potential
APE	Area of Potential Effect
ARD	Acid Rock Drainage
ARM	Administrative Rules of Montana
ATSDR	Agency for Toxic Substance and Disease Registry
BACT	Best Available Control Technology
BAT	Best Available Technology Economically Achievable
BCI	Bat Conservation International
BIA	U.S. Bureau of Indian Affairs
BLM	U.S. Bureau of Land Management
BMP	Best Management Practices
BP	Before Present
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environment Response, Compensation and Liability Act
CERCLIS	CERCLA Information System (potential Superfund sites list)
CERT	Council of Energy Resource Tribes
CFR	Code of Federal Regulations
CMR	Charles M. Russell National Wildlife Range
COE	U.S. Army Corps of Engineers
CPA	Company Proposed Action
CWA	Clean Water Act
DEQ	Montana Department of Environmental Quality
DHES	Montana Department of Health and Environmental Sciences
DMR	Discharge Monitoring Reports
DNRC	Montana Department of Natural Resources and Conservation
DOJ	Department of Justice
DSL	Montana Department of State Lands
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FBCC	Fort Belknap Community Council
FLPMA	Federal Land Policy and Management Act of 1976
GWPCS	Groundwater Pollution Control System
HDPE	High Density Polyethylene
HELP	Hydraulic Evaluation of Landfill Performance

IHS	Indian Health Service
IMP	Island Mountain Protectors
KOP	Key Observation Point
LAD	Land Application Disposal
LCNHT	Lewis and Clark National Historic Trail
MBF	Thousand Board Feet
MCA	Montana Code Annotated
MDFWP	Montana Department of Fish, Wildlife and Parks
MEPA	Montana Environmental Policy Act
MFSA	Montana Major Facility Siting Act
MGWPCS	Montana Groundwater Pollution Control System
MMCF	Million Cubic Feet
MMRA	Montana Metal Mine Reclamation Act
MNHP	Montana Natural Heritage Program
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPDES	Montana Pollutant Discharge Elimination System
MPM	Montana Principal Meridian
MSL	Mean Sea Level
NAAQS	National Ambient Air Quality Standards
NAG	Non-Acid Generating
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NNP	Net Neutralization Potential
NP	Neutralizing Potential
NPDES	National Pollutant Discharge Elimination System
NPNHT	Nez Perce National Historic Trail
PA	Programmatic Agreement
PSD	Prevention of Significant Deterioration
PVC	Polyvinyl Chloride
PWSA	Public Water Supply Act
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RFRA	Religious Freedom Restoration Act
RMA	Recreation Management Area
RMP	Resource Management Plan
ROD	Record of Decision
RSPS	Reclamation Surface Performance Study
RUSLE	Revised Universal Soil Loss Equation
SHPO	Montana State Historic Preservation Office
TCP	Traditional Cultural Property
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
USDOC	U.S. Department of Commerce
USDI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VRM	Visual Resource Management
WQA	Water Quality Act
WSA	Wilderness Study Area
ZMI	Zortman Mining, Inc.

UNITS OF MEASURE

mg/l	milligrams per liter
mg/Kg	milligrams per kilogram
tpy	tons per year
lb/ton	pounds per ton
ppm	parts per million
gpm	gallons per minute
cm/sec	centimeters per second
cy	cubic yards
cfs	cubic feet per second
Kg/day	kilograms per day
ft/day	feet per day
ft^2/day	square feet per day
mph	miles per hour
$\mu g/m^3$	micrograms per cubic meter
μg/Kg	micrograms per kilogram
dB	decibel
g	gravity
g/Kg	grams per kilogram
KT	kiloton

CHAPTER 1.0

INTRODUCTION - PURPOSE AND NEED

This Final Environmental Impact Statement (EIS) discloses the environmental consequences associated with expansion of the Zortman and Landusky mines in north central Montana and modified reclamation plans at both mines. The Company Proposed Action (to extend the mine life at the Zortman and Landusky mines and reclaim both mines), and alternatives to the proposed action, have been evaluated by the Montana Department of Environmental Quality (DEQ) Hard Rock Bureau (formerly Montana Department of State Lands - DSL), U. S. Department of the Interior, Bureau of Land Management (BLM), and a third-party consultant (Woodward-Clyde). Environmental issues and concerns expressed by the public and other agencies during EIS scoping have been considered and incorporated into this analysis. The Final EIS is prepared under requirements of the National Environmental Policy Act (NEPA), for BLM purposes; and the Montana Environmental Policy Act (MEPA), for DEQ purposes.

This chapter of the EIS includes:

1. A brief description of the proposed Zortman and Landusky mine extensions and reclamation measures and a permitting history of each

2. An explanation of the purpose and need for the project, and for agency preparation of the EIS

3. A summary of the steps taken in the EIS process

4. A list of the major authorities and statutory responsibilities of the various agencies which have a role in the environmental analysis or permitting decision

5. A summary of the issues and concerns expressed by the public during project scoping, including those issues raised but not addressed in the Final EIS and why

1.1 PROJECT HISTORY

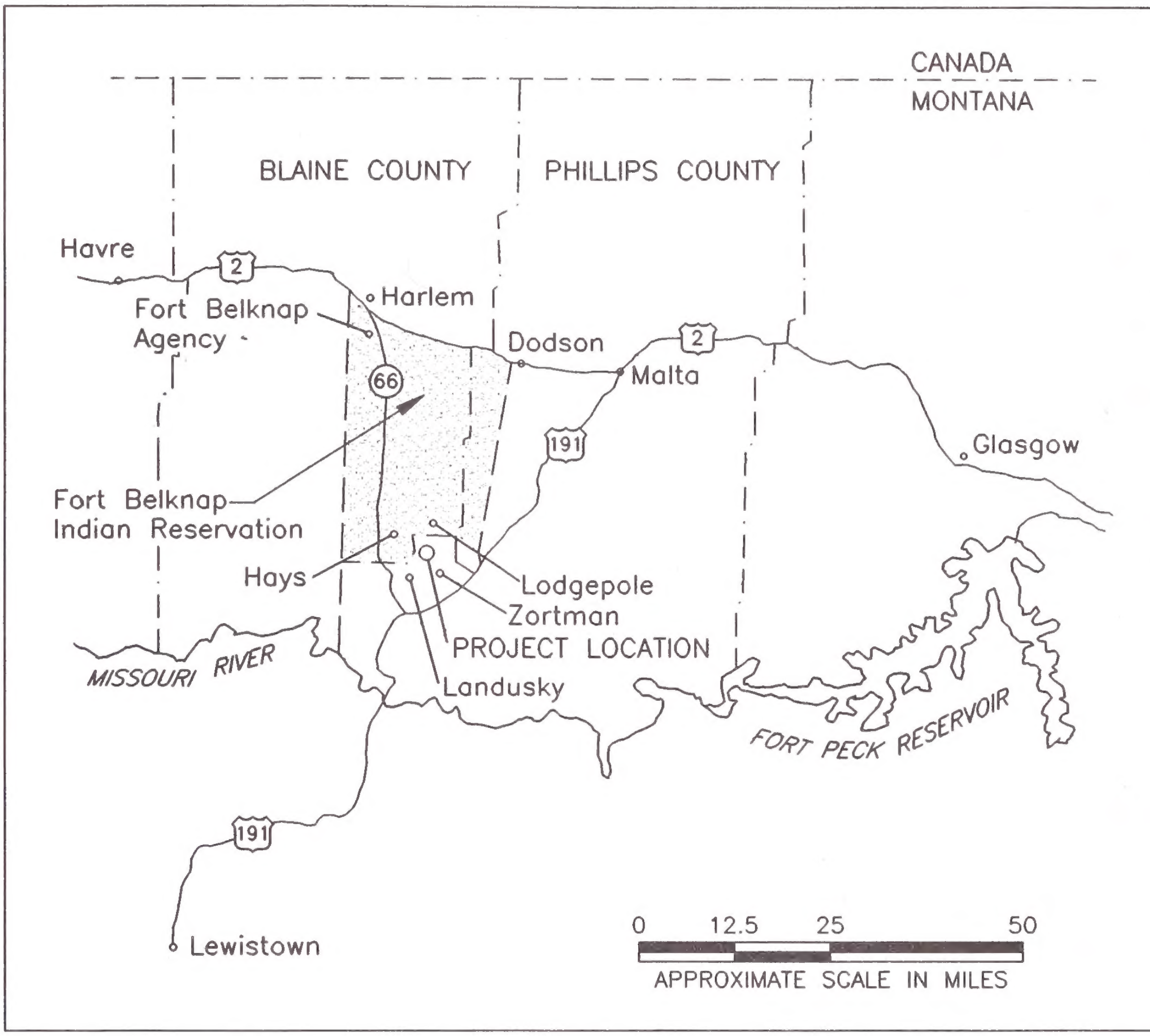
Zortman Mining, Inc. (ZMI) since 1979 has had two active gold and silver mines in close proximity in the Little Rocky Mountains of north central Montana. The Zortman Mine is located in Sections 7, 17, and 18, Township 25N, Range 25E, Montana Principal Meridian (MPM); while the Landusky Mine is west of the Zortman Mine in Sections 14, 15, 22, and 23, Township 25N, Range 24E, MPM. Both mines are near the southern boundary of the Fort Belknap Indian Reservation in the southwest corner of Phillips County (Figure 1-1). The towns of Hays and Lodgepole are located in the southern portion of the Reservation, just to the north of the mountains. The town of Landusky is in the southwest portion of the Little Rocky Mountains, about 0.5 mile south of the Landusky Mine. The town of Zortman is about 1 mile south of the Zortman Mine, on the southern edge of the Little Rocky Mountains.

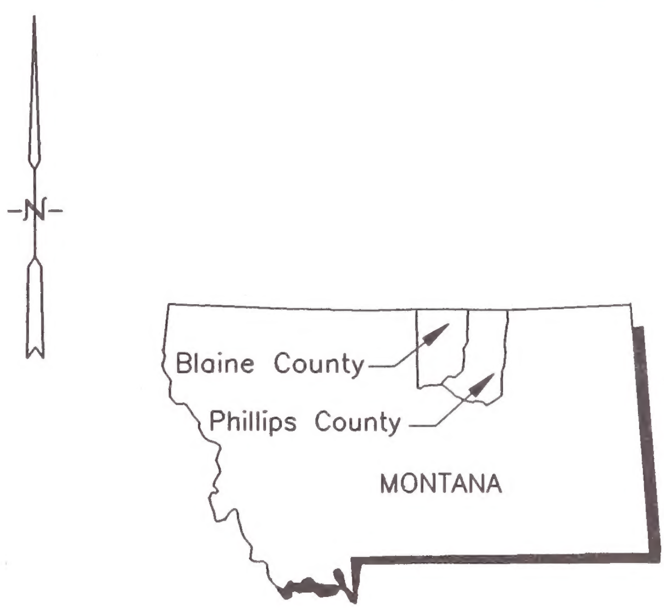
Historic mining has occurred in the area over the past century. Photos of the Zortman and Landusky mining area and towns in 1977 (Figures 1-2 and 1-3) show the amount of disturbance before the era of large-scale, modern mining began (about 1979). Note that at Zortman, disturbance in 1977 was confined primarily to the Linda K Mine in the northwest (upper left) of the picture, to the Ruby Mine and Mill and mill tailing deposition in Ruby Gulch in the center of the picture, and to numerous access and exploration roads. The town of Zortman (arrow, lower right) appears much as it does today.

At Landusky, the photo from 1977 shows disturbance from historic mining activity at the Gold Bug and Little Ben mines, among the exploration/drill roads in the center (Figure 1-3). At the top of the photo, the August Mine, mill, and tailing dam remnants are present, with tailing extending downstream along King Creek towards the Fort Belknap Indian Reservation. Remains of the tailing dam and tailing are evident today. The town of Landusky (arrow, lower center) has remained mostly unchanged in appearance through the decades.

Figures 1-2 and 1-3 are contrasted to Figure 1-4, an aerial photo showing disturbance in 1993. In Figure 1-4, the distance between the two mines is about 1.5 miles. The Zortman Mine and Ruby Gulch tailing are in the foreground for reference. The photo illustrates the amount of land disturbance which has occurred since large-scale mining began in 1979. The disturbance acreages are detailed under the discussions of each mine below and in the accompanying tables.

In 1979, a Draft EIS pertaining to both mines was prepared by the Montana Department of State Lands (DSL 1979a). The Final EIS documentation (responses to comments on the Draft EIS and adoption of the Draft as Final) was issued May 17, 1979 (DSL 1979b).





SOURCE: DSL/BLM 1990.

LOCATION OF ZORTMAN
AND
LANDUSKY MINE EXPANSIONS

MONTST

FIG. 1–1

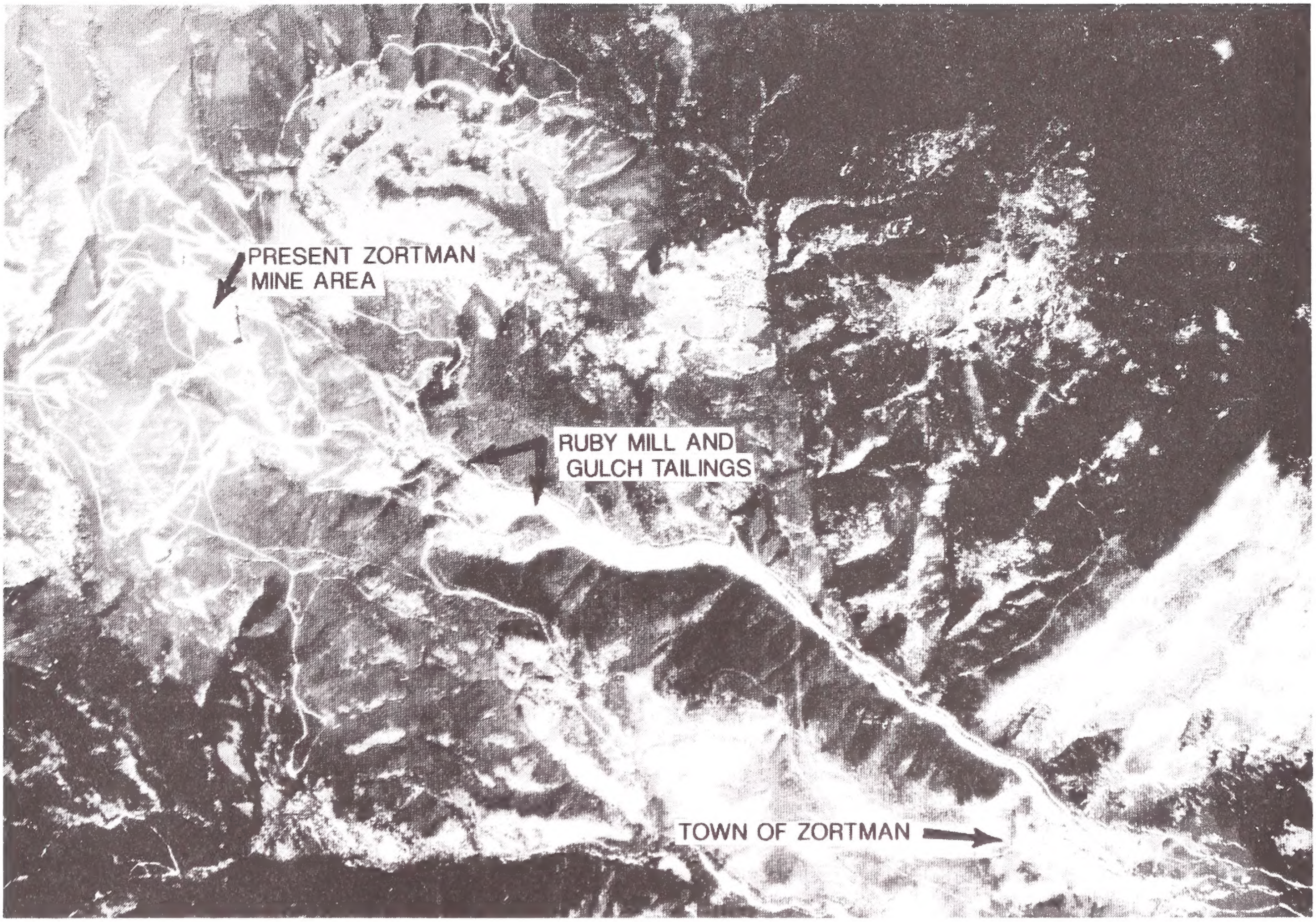
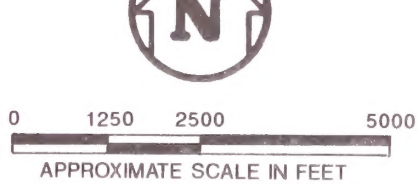


Figure 1-2 The Zortman Mine area (upper left) and town site (lower right, arrow) showing disturbance as of June 1977. Ruby Gulch tailings are in center of photo (ZMI 1994).



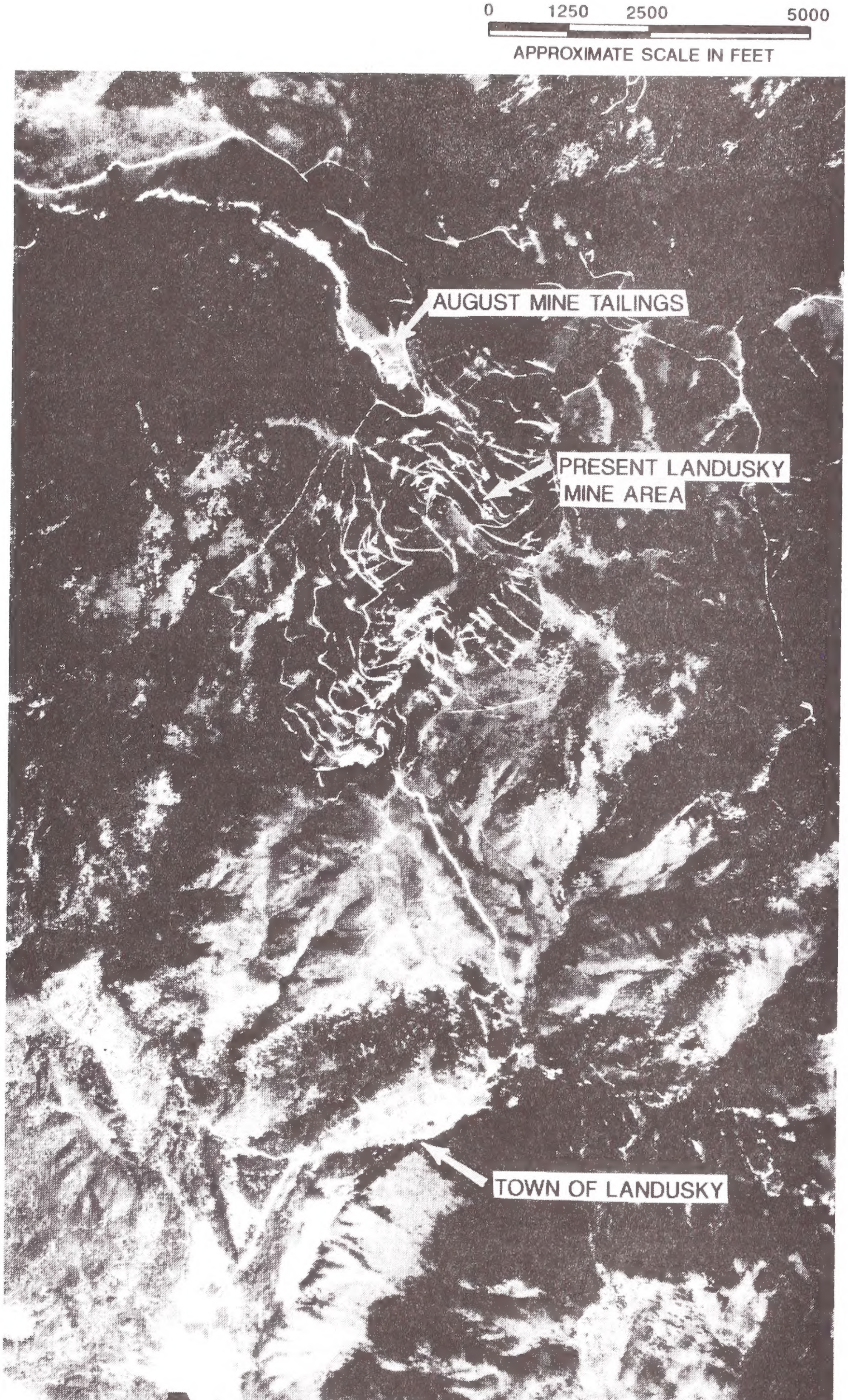


Figure 1-3 The Landusky Mine area (center, with exploration roads) and town site (arrow, bottom) are shown in June, 1977. Minor mining disturbances and remains of the August Mine tailings (top) are noted. (ZMI 1994).

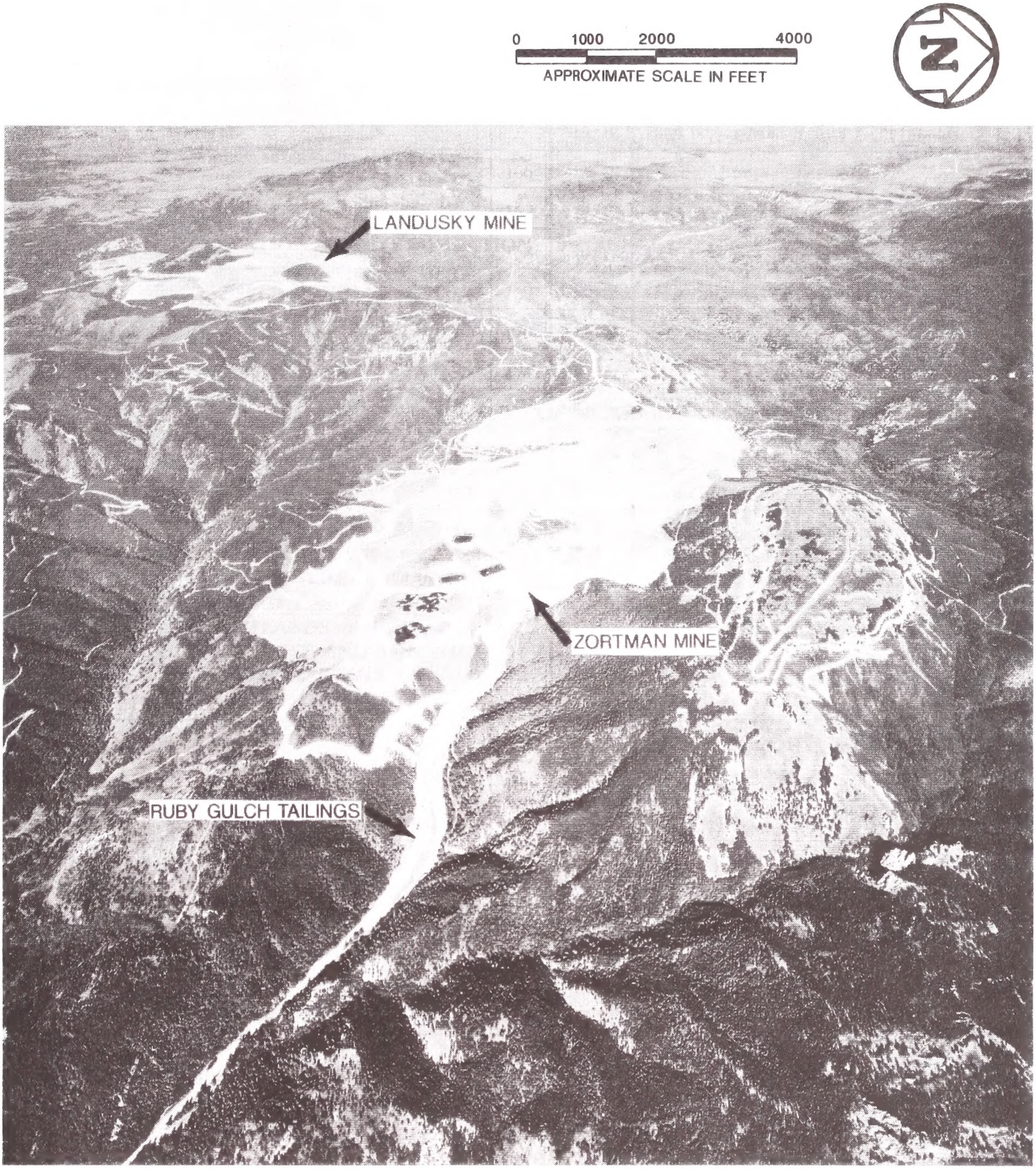


Figure 1-4 Zortman Mine (foreground) and Landusky Mine (background) showing areas of disturbance (as of 1993) in the Little Rocky Mountains, looking west. Roads and cleared areas from past logging, forest fires, and mineral exploration are also shown (ZMI 1993).

These documents discussed proposed operations of the Zortman Mining Company (Gulf Resources) to develop 273 acres, and of the Landusky Mining Company (Wharf Resources) to develop 256 acres. Baseline conditions were described and impacts assessed for the physical, biological, and social and economic environments. These early documents formed much of the basis for the discussion of impacts caused by mining from 1979 to the present as analyzed in this current Final EIS.

The permitting history of each mine is useful to an understanding of the current situation and is presented in the next sections.

1.1.1 Zortman Mine

ZMI, a wholly owned subsidiary of Pegasus Gold Corporation of Spokane, Washington, holds an approved Federal Plan of Operations MTM-77778 and State Operating Permit No. 00096 to mine and recover gold, silver, and associated minerals at the Zortman Mine. The original State permit authorizing mining at the Zortman Mine was issued by the DSL in 1979. Subsequent revisions to the operating and/or reclamation plans have been analyzed pursuant to the MEPA and NEPA to allow increases in the disturbance area to that shown on Figure 1-4. These actions are summarized in Table 1-1.

1.1.2 Landusky Mine

At the Landusky Mine, ZMI holds an approved Federal Plan of Operations MTM-77779 and State Operating Permit No. 00095 for mining and reclamation activities. As shown in Table 1-2, ZMI's State Operating Permit 00095 was originally issued June 6, 1979. Subsequent revisions to the operating and/or reclamation plans at Landusky have been analyzed pursuant to MEPA and NEPA to allow increases in the disturbance area to that shown on Figure 1-4.

In the most recent year of production (1995), both mines produced a combined 110,800 ounces of gold and 500,481 ounces of silver. About 90 percent of this production is from Landusky (ZMI 1996).

1.1.3 Other Documentation and the Acid Rock Drainage Issue

Other events are worth noting concerning acid rock drainage (ARD), which is one of the key EIS issues (see ARD sidebar on 3rd page following). A chronology is as follows:

- May 1992 - ZMI submits Zortman Mine Life Extension Application.
- Summer 1992 - Based on ongoing field inspections and a review of water quality monitoring data (1985-1992), BLM and DSL note that ZMI's approved operating and reclamation plans are not adequate to address ARD.
- November 1992 - BLM (1992a) sends a letter to ZMI, and ZMI responds, regarding development of low pH in effluent from various facilities.
- January-February 1993 - DSL (1993a) sends two letters to ZMI with situation reports requiring changes in mine operations to address ARD. ZMI responds with proposed changes regarding water quality problems.
- April 1993 - BLM State Director issues decision (BLM 1993a) requiring modification of Zortman and Landusky mine plans to prevent unnecessary or undue degradation from ARD.
- July 1993 - ZMI provides remediation plans for Landusky Mine and revises Zortman expansion plans to include remediation of existing facilities.
- August 1993 - BLM District Manager issues Notices of Noncompliance to ZMI for violation of the Clean Water Act based upon correspondence sent from U.S. Environmental Protection Agency (EPA) to ZMI (EPA 1993a).
- November 1993 - Supplemental Environmental Assessment (EA) for Landusky, specifically addressing ARD control, is issued (DSL/BLM 1993a).
- March 1994 - The Decision Record on corrective measures to address ARD at Landusky (DSL/BLM 1994a) is issued, withholding approval of final long-term reclamation and closure designs until this EIS is prepared. The agencies also decide to include corrective measures for the Landusky Mine within the scope of the environmental impact analysis for the Zortman Mine extension.

TABLE 1-1
AMENDMENTS TO OPERATING PERMIT 00096 AND PLAN OF OPERATIONS MTM-77778 (ZORTMAN)

Permit or Amendment No.	Year	Purpose[1]
Operating Permit 00096 and Plan of Operations MTM-77778	1979	Includes pit, 79, 80/81 leach pad, process plant, ponds, OK dump; total disturbance 273 acres, permit boundary encloses 619 acres
Amendments		
001	1979	Access road up Ruby Gulch - total permitted disturbance 276 acres
002	1980	6300 foot haul road - increase disturbance to 281 acres
003	1980	New location for process plant and ponds - no change in disturbance - total permitted disturbance 281 acres
004	1982	Correction for nondisturbance - total permitted disturbance 155 acres
005	1982	83/84 leach pad - total permitted disturbance 186 acres
006	1983	83/84 leach pad expansion - total permitted disturbance 267 acres
007	1984	Expansion of pit, pads, and dumps - total permitted disturbance 391 acres
008	1984	85/86 leach pad - total permitted disturbance 436 acres
009	1987	Land application area, increase in permit boundary to enclose 961 acres - total permitted disturbance 436 acres
009A	1987	Storm water ponds - no change in total permitted disturbance 436 acres
010	1988	89 leach pad and correction for nondisturbance - 401 acres total permitted disturbance
011	1989	Revised reclamation plan, no new disturbance - 401 acres total permitted disturbance - permit boundary encloses 961 acres

Notes:

[1] The project areas and features are explained and mapped in detail in Chapter 2.0 of this EIS.

Source: DSL 1995.

TABLE 1-2
AMENDMENTS TO OPERATING PERMIT 00095 AND PLAN OF OPERATIONS MTM-77779 (LANDUSKY)

Permit or Amendment No.	Year	Purpose[1]
Operating Permit 00095 and Plan of Operations MTM-77779	1979	Permit boundary encloses 530 acres; total allowable disturbance 256 acres
Amendments		
001	1980	Leach pad expansion - increase disturbance to 267 acres
001A	1982	Decrease disturbance to 163 acres due to increased resolution of aerial mapping
002	1982	Soil stockpile and access road; increase disturbance to 282 acres
002A	1982	Decrease disturbance to 194 acres due to increased resolution of aerial mapping
003	1983	Montana Gulch leach pad and pit expansion - increase disturbance to 251 acres
004	1984	Montana Gulch waste rock dump and pit expansion - increase disturbance to 383 acres
005[2]	1985	
006	1985	Queen Rose pit expansion - increase permit area to 830 acres
007	1986	Mill Gulch (87) leach pad
008	1988	Mill Gulch waste rock dump
009	1990	Mill Gulch leach pad expansion
010	1990	Sullivan Park (91) leach pad (total permit area 1,287 acres and total disturbance area 814 acres)
---	1994	Interim reclamation and corrective measures approved

Notes:

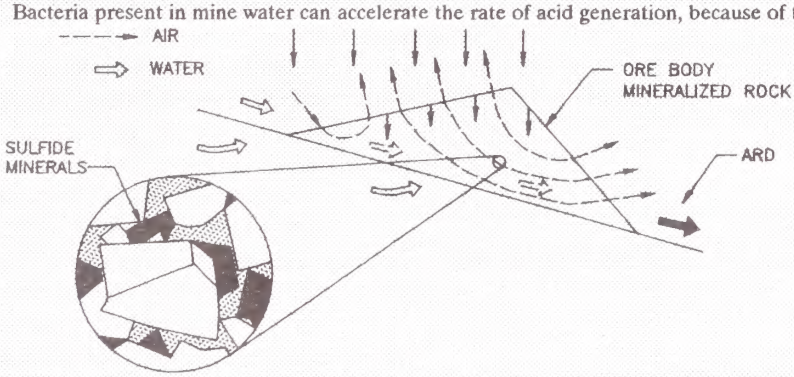
[1] The project areas and features are explained and mapped in detail in Chapter 2.0 of this EIS.
[2] Amendment was not issued.

Source: DSL/BLM 1991a.

Acid Generation

Acid produced by Acid Rock Drainage (ARD) or Acid Mine Drainage (AMD) is a key issue of concern at the Zortman and Landusky mines. It is also a problem for miners and officials responsible for mine restoration and environmental protection throughout the United States, North and South America, and the world. In the U.S., our regulatory environment is now focusing attention on ARD issues at many mining sites.

Simply stated, ARD is produced when rock containing sulfides (such as iron sulfide, or the "fools gold" familiar to many of us) is exposed to air and water during mining operations. Water traveling through the rock becomes acidic, and sometimes contains metals such as lead, arsenic, zinc, copper, and silver. Bacteria present in mine water can accelerate the rate of acid generation, because of their ability to oxidize sulfide-bearing metals.



Many gold and silver ore bodies, such as those at the Zortman and Landusky mines, have the right conditions for ARD (which has been detected at many facilities here). Impacts can occur to aquatic plants and small animals, fish, and humans, as they are affected by degraded water quality in surface streams and drinking water wells.

Sources: See *Suggested Readings* in the References Section regarding articles and reports on acid generation. Figure above adapted from Hutchinson and Ellison (1992).

1.2 PROPOSED ACTION

1.2.1 General Description

At the Zortman Mine, the current permit area encloses 961 acres of land, of which 401 acres are currently disturbed. ZMI has submitted a new application seeking approval for expanded mining and reclamation activities. The proposed project includes mining an additional 80 million tons of ore and 60 million tons of waste rock, as well as enhanced reclamation for existing disturbances. The projected mining rate is 21 to 28 million total tons per year. Mining is proposed to proceed at these rates for approximately 5 to 8 years.

At Landusky, the current permit area encloses 1,287 acres and approximately 814 acres of disturbance. The proposed expansion includes mining an additional 7.6 million tons of ore and 7 million tons of waste rock, and enhanced reclamation of existing pits, leach pads, and waste rock dumps.

About 594 acres of public land managed by BLM are currently disturbed by existing mining activities.

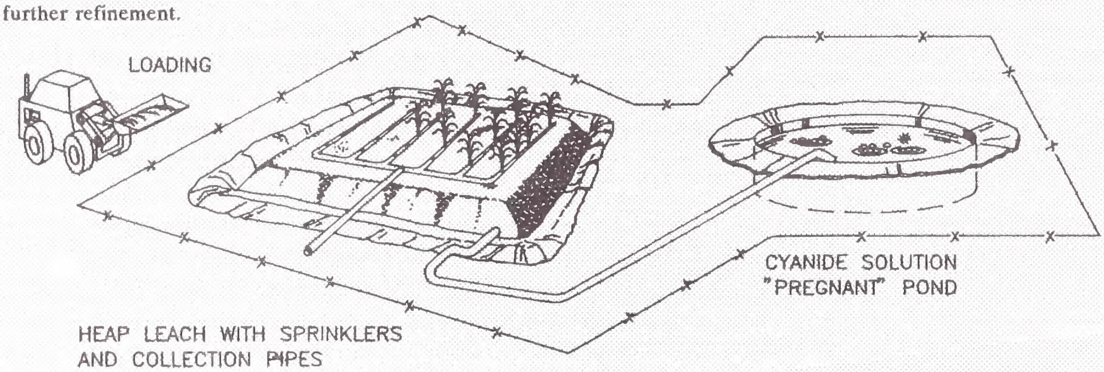
Approximately 242 additional acres of public land managed by BLM (of the total new disturbance of about 955 acres) would be affected by the Company Proposed Actions for the Zortman and Landusky mine extensions and reclamation activities. Therefore, about 25 percent of the proposed new surface disturbance could occur on public land managed by BLM. The land use impacts section (4.7) of this EIS provides additional details on public and private lands affected.

1.2.2 Zortman Mine

Under the proposed action to expand the Zortman Mine, existing mine pits would be widened and deepened, and a new waste rock repository would be constructed. A conveyor system to transport ore would extend from the mine process area southeast approximately 12,000 feet to a new cyanide heap leach pad (see Cyanide sidebar) in Goslin Flats. Open-pit mining methods would continue to be used to remove

Cyanide Use in Mineral Processing

Cyanide heap leaching is a relatively new technology in mining that is used for recovery of microscopic gold particles typically found in low-grade ore deposits. The ore zones at the Zortman and Landusky mines contain such microscopic gold. Past and current mine activities, and proposed mining, include the use of this process to extract gold from the host rock. Simply stated, low grade ore is drilled, blasted loose, crushed, and loaded into trucks or conveyors for transfer to the leach pad. The pad is not just an ore dump, but a carefully constructed series of flat-topped heaps. It is lined with plastic and/or clay to prevent loss of solution. The leach pad is further constructed in lifts, which are sequentially sprayed with the cyanide solution using a surface sprinkler system, much like those used to keep big lawns irrigated. A "pregnant solution" containing the gold particles is collected, processed in tanks or treatment cells, and heated in a furnace to form impure gold/silver doré bars for further refinement.



Environmental concerns regarding cyanide use include harmful concentrations of cyanide in water. Occasionally, cyanide has been detected in groundwater at the Zortman and Landusky mine sites. Properly-managed cyanide use will not produce harmful effects to wildlife and humans. Cyanide releases to the environment, whether gas or liquid, can degrade quickly into less harmful ammonium, nitrate or carbon dioxide. Various treatment processes are used at the mines to detoxify the cyanide heaps, ponds and other facilities; and nets and other measures are used on ponds to prevent use by waterfowl and shorebirds.

Sources: See *Suggested Reading* in the References Section regarding articles on cyanide use and management. Figure above adapted from Wargo (1992).

gold, as well as silver oxide and sulfide ores. Approximately 20,000 to 40,000 tons of ore would be processed per day, 350 days per year. These processing activities are expected to yield 100,000 ounces of gold and 300,000 ounces of silver annually.

ZMI submitted the proposed amendment to the Zortman Plan of Operations MTM-77778 and Operating Permit No. 00096 to the agencies in May, 1992, requesting a modification to the Zortman mining permit. DSL and BLM reviewed the application and notified ZMI that the application was incomplete and requested additional information regarding the proposed action. After further rounds of information submittal by ZMI, and requests for clarification or additional information by DSL and BLM, the application was determined to be complete on July 9, 1993. A final decision on the amendment application will be made after this EIS is completed.

1.2.3 Landusky Mine

At the Landusky Mine, an additional 7.6 million tons of ore and 7 million tons of waste rock would be mined as part of the overall mining and reclamation plan.

ZMI would continue to use open-pit mining and heap-leach mineral processing to extract gold and silver from ore. The quantity of ore to be mined under this application would constitute slightly less than one year of additional mining at the facility. No additional workers are anticipated to be hired under this expansion proposal. About 42,000 total tons of material would be mined per day at Landusky during that year. During this one year of operations, about 50,000 ounces of gold and 150,000 ounces of silver are expected to be produced.

The mined material would come from the August and South Gold Bug pits (see detailed figures in Chapter 2.0). Various tables in Chapter 2.0 provide a summary of currently permitted and disturbed acreages, proposed increases in disturbance area, and tons of ore and waste, both mined and proposed to be mined. A final decision on modifications to Plan of Operations MTM-77779 and Operating Permit No. 00095 for Landusky will similarly await completion of this EIS.

1.3 PURPOSE AND NEED FOR ACTION

Gold and silver are produced and used on a world-wide basis. Global gold supply in 1993 was estimated to be 3,538 tons (Goldfields Mineral Services, Ltd. 1994). Domestic mines continued to produce at near record levels during 1994, maintaining the United States' position as the world's second largest gold-producing nation, after the Republic of South Africa. U.S. production of 330 tons in 1994 accounted for about 15 percent of world-wide gold production (USDI Bureau of Mines 1995). In the U.S. in 1994, gold was produced from about 200 lode mines, about a dozen large placer mines, and numerous small placer mines.

Global demand has increased significantly since 1980. Jewelry is the largest single use, involving an estimated 70 percent of the gold supply. Gold held for investment was the second largest use (gold jewelry often doubles as an investment). Other uses, such as electronics, dental, coinage and other miscellaneous industrial uses, comprised about 15 percent of total demand (Goldfields Mineral Services, Ltd. 1994).

Silver is used extensively in photography, chemistry, and jewelry. Because of its high conductivity, it is used widely in electronics. Often as an alloy, it is a worldwide currency. It is also used to line vats in chemical reactive vessels, and in water distillation. Familiar uses in the home and workplace include mirrors; silver plating; table cutlery; dental, medical, and scientific equipment; and in brazing alloys and solder.

Approval of ZMI's applications for permit modifications at the Zortman and Landusky mines would allow continued extraction (mining), beneficiation (heap leaching), and recovery of gold, silver, and other metals from the two mines for a period of 5 to 8 more years. ZMI has cited the mines' beneficial economic impact on tax revenues and the communities near both mines. The mine expansions would continue to employ approximately 260 persons through project construction and mine operation, as the existing operations phase out. An additional 5 to 25 persons would be employed during the approximate 10-year post-operations reclamation period (see Section 4.10, Socioeconomics).

The agencies' purpose and need for this action is to address two basic issues: (1) <u>mineral development</u> needs; and (2) <u>environmental protection</u> needs. In the first matter, the lands in the project area are either private lands or public lands open to mineral development and the operator has properly filed for approval of mineral development activity under relevant state and federal laws and regulations. Secondly, the agencies have determined that existing operation and reclamation plans are not adequate to prevent unacceptable impacts from ARD. As stated previously (Section 1.1.3), modified reclamation plans are required. However, while expansion of the mines and extension of the life of the two mines *is* dependent on the proper performance of reclamation and remediation, the reclamation and remediation actions are *not* co-dependent on further mining. Adequate reclamation materials, in other words, are available without further mine production.

The agencies' consideration of the permit modifications proposed by ZMI, as detailed above, constitute state and federal actions which may significantly affect the quality of the human environment under MEPA and NEPA, necessitating the preparation of an EIS.

This Final EIS presents the agencies' analysis of environmental impacts under NEPA and MEPA regulations and guidelines. DEQ and BLM will use the analysis in this Final EIS to make final decisions regarding issuance of the Operating Permit and Plan of Operations. The responsibilities of each agency are described further in the sections which follow. Other state and federal agencies may use this Final EIS as the NEPA/MEPA document required for their permit decisions.

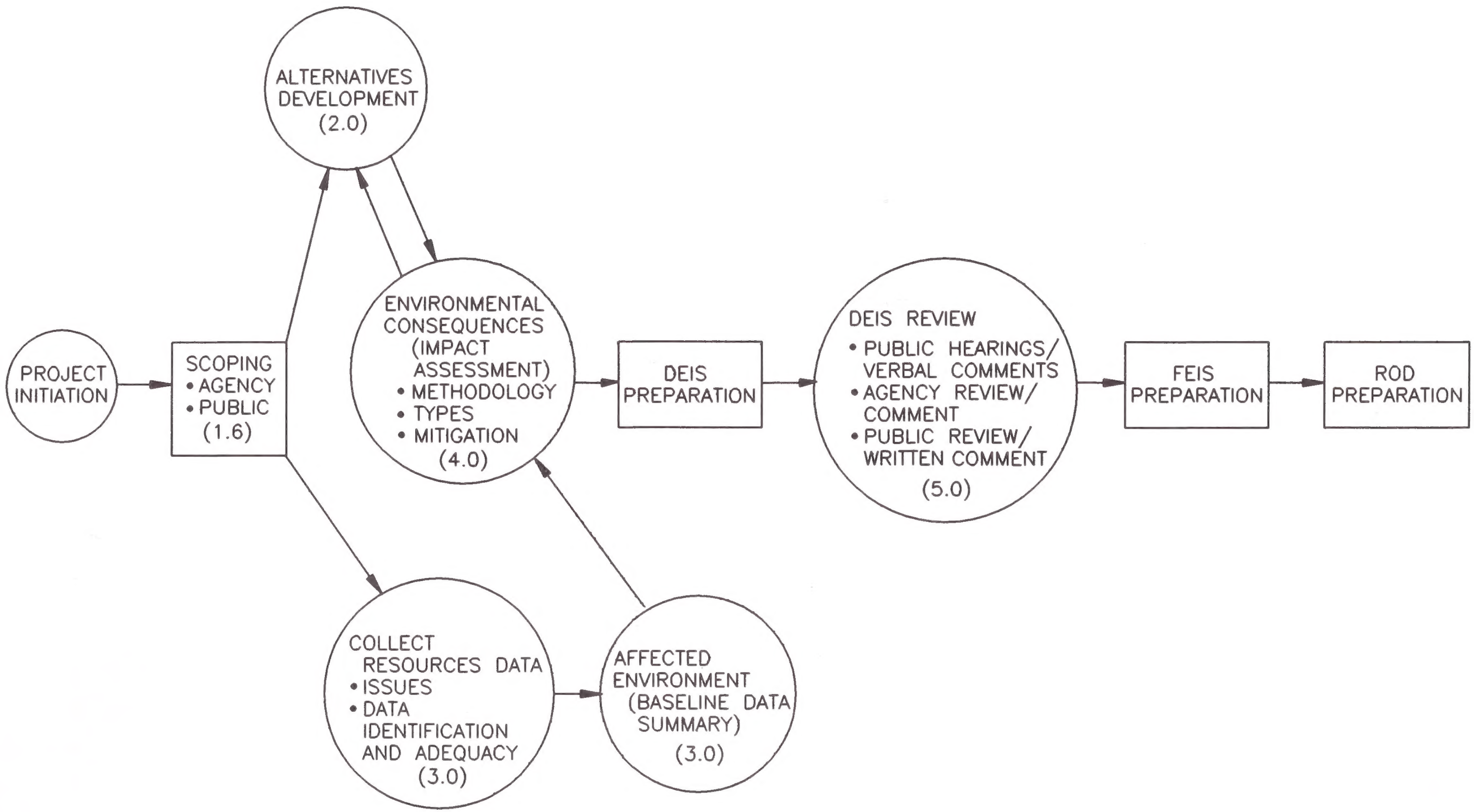
1.4 THE EIS PROCESS

The MEPA requires that a detailed statement regarding environmental impacts, alternatives, and other requirements be prepared for proposals of projects or major actions which significantly affect the quality of the human environment (§75-1-201(1)(b)(iii), MCA). DEQ (formerly DSL) rules implementing MEPA at ARM 26.2.644 require preparation of an EIS if impacts associated with a proposed action may have a significant adverse effect. Similarly, NEPA requires that if any major action taken by a federal agency might significantly affect the quality of the human environment, an EIS must be prepared (NEPA, P.L. 91-190, 42 U.S.C 4321 <u>et seq</u>., Section 102(2)(c)). DEQ and BLM have determined that an EIS is required in order to make a permitting decision regarding ZMI's application.

The steps in development of the Zortman and Landusky EIS, and where such steps are addressed in this document, are shown on Figure 1-5.

FIG. 1–5

MAJOR PHASES OF THE EIS PROCESS



( ) SECTION OF THIS EIS DOCUMENT WHERE THIS ITEM IS ADDRESSED.

1.5 REGULATORY AUTHORITY AND RESPONSIBILITIES

DEQ and BLM (in this document, referred to as "the agencies") are the joint lead agencies responsible for preparation of the Final EIS, and for issuing a final decision regarding the mine permit application. For purposes of impact evaluation, technical expertise was provided by an independent third-party consultant selected by, and working under the direction of, DEQ and BLM. The agencies will consider the proposed action and alternatives presented in this EIS and issue a decision on the permits and approvals required from the agencies for the Zortman and Landusky mine extension projects. The final decisions and rationale will be presented in a document or documents known as the Record of Decision(s). More details concerning various lead and supporting agency responsibilities are presented below.

1.5.1 Montana Department of Environmental Quality (Formerly Montana Department of State Lands)

Operating Permit

The purpose of the 1971 Montana Metal Mine Reclamation Act (MMRA) is to ensure that the usefulness, productivity and values of lands and waters disturbed by mining receive the greatest reasonable degree of protection and reclamation to a beneficial use. This Act applies to all lands within the State of Montana, whether federal, state, or private. Under this Act, DEQ has the authority (a) to issue an operating permit, (b) to inspect facilities and operations for compliance with the permit and applicable laws, and (c) to check the company's self-monitoring. Before DEQ can issue an operating permit, a reclamation bond must be posted with the agency and must be of sufficient amount for the state to complete reclamation in the case of default by the operator.

Bonds for reclamation of lands disturbed under a mine operating permit are based on requirements for water treatment, demolition and removal of surface facilities, earth moving, soil replacement, seedbed preparation including amendments, and revegetation. An itemized list of costs for applicable tasks is prepared using information derived from the approved operating and reclamation plan. Bond amounts are subject to review at least every five years. In addition, the BLM can require a reclamation bond if it deems the state's bond inadequate.

The current reclamation bond amount is $25 million for both mines ($10 million for Zortman, $15 million for Landusky). Once an alternative has been selected, a new reclamation bond amount would be calculated based upon the cost for the agencies (not the operator) to implement the approved reclamation plan. Release of the reclamation bond on BLM surface is made by DEQ subject to BLM concurrence upon completion of successful reclamation. An environmental site assessment would be required for final bond release.

Some reclamation costs are not appropriately covered by performance bond. Costs for emergency response water treatment or facility maintenance which extend for an indefinite period are examples. In these cases, DEQ requires the mining company to establish a trust fund which is of sufficient size that annual interest income meets anticipated annual expenditures for as long as is required. This trust is in addition to normal reclamation bonding.

Mine pit reclamation is also regulated by DEQ under 82-4-336 *et seq.* MCA, wherein authority is granted DEQ to require mine reclamation plans.

Pit reclamation is considered in this EIS in several places. Section 2.1 identifies pit reclamation as a significant issue related to mine pit expansion. Section 2.2.6 contains a summary of alternatives reviewed and either eliminated from further consideration or included as a component of one of the seven final alternatives analyzed in this document. Partial backfill, complete backfill, and pit highwall reduction are considered in this section as well as in section 2.2.5, which specifically addresses some of the environmental and economic issues associated with pit backfill. In addition, all of the alternatives developed for further consideration in the impact analysis (Chapter 4.0) contain provisions for pit reclamation, including varying degrees of pit backfill.

Discharge Permit

DEQ is also responsible for administration of Title 75, Chapters 5 and 6, MCA, better known as the Water Quality Act (WQA) and the Public Water Supply Act (PWSA), respectively. DEQ is also responsible for administering several programs under the Federal Clean Water Act (CWA) pursuant to delegation agreements with the U.S. Environmental Protection Agency (EPA). Two of these programs are the National Pollutant Discharge Elimination System (NPDES), delegated pursuant to 40 CFR 123, and water quality standards pursuant to 40 CFR 131. Facilities which discharge to State water must obtain a state discharge permit and comply with both State and Federal regulatory requirements as administered by DEQ.

Zortman Mining, Inc. holds a Montana Pollutant Discharge Elimination System (MPDES) permit (MT-0024864) for the Landusky mine, which authorizes discharge of storm water into King Creek, and another permit (MT-002485) for discharge of treated water into Ruby Gulch and Glory Hole Creek. MPDES permits must be renewed every five years. ZMI requested that these permits be renewed in late 1991, and DEQ issued a Public Notice on March 9, 1992 with the intent to renew these permits. After reviewing ZMI's Annual Water Resources Report for 1991, DEQ became concerned about deteriorating water quality in the vicinity of the Zortman and Landusky mines. During the ten years ZMI held valid discharge permits (1981 to 1991), the company had reported no discharge on their Discharge Monitoring Reports (DMR) submitted to DEQ. Despite this condition, water quality monitoring showed decreasing pH values and increasing concentrations of metals and sulfate in State waters.

In April 1993, DEQ sent ZMI a request for additional information and completed an on-site inspection of the mine site. The EPA also sent ZMI a request for information under Section 308 of the Federal CWA. DEQ and EPA conducted a joint inspection of the mine sites in May, 1993 and identified several water quality violations. On July 18, 1993 EPA sent formal notification to DEQ and ZMI of violations of the Federal CWA. (Under delegation provisions of the Federal CWA, DEQ has primary authority for enforcement of violations of the CWA.)

On August 30, 1993, DEQ (then known as Montana Department of Health and Environmental Sciences, DHES) filed a Civil Complaint and Application for Injunction (Cause No. BOV 93-1511) in District Court in Lewis and Clark County, Montana, naming Pegasus Gold Corporation and Zortman Mining, Inc. (Pegasus/ZMI) as defendants. The Complaint alleges violations of the Montana WQA in each of seven drainages. These violations include: the placement of wastes in a location likely to cause pollution of state waters; discharge of wastes to state waters without a valid permit; and, violations of Montana water quality standards in both surface and groundwater. The Complaint seeks a prohibition of all waste discharges and further mining activities unless ZMI: (1) submits and implements an DEQ-approved Improvement Plan providing for corrective measures and monitoring; (2) makes application for an MPDES permit or stops discharging wastes to State water; and (3) pays civil penalties as specified in the WQA. The complaint was later amended on October 13, 1993.

In May 1994, the District Court ruled on several preliminary motions in this case. One of these motions granted intervenor status to Island Mountain Protectors (IMP). On February 15, 1995, the Montana Supreme Court ruled on the motions in favor of DHES.

ZMI submitted an expanded MPDES permit application in the fall of 1993 and a Improvement Plan in March 1994. The Improvement Plan has undergone several revisions and is under review by DEQ, EPA, and IMP. In processing the discharge permit application, DEQ determined that adequate hydrologic and water quality baseline data did not exist prior to the current mining activities. This information is necessary to develop water quality-based effluent limits in the discharge permit. Therefore, the Improvement Plan has been expanded to include additional data collection. A discharge permit may not be issued for several years. A court-approved Improvement Plan and Schedule would replace the discharge permit and establish interim effluent limits and conditions until a MPDES permit could be developed.

In 1994, ZMI began construction of a waste water treatment facility at the Zortman mine to treat acid rock drainage. Both the Water Quality Act and the Public Water Supply Act required DHES approval of wastewater treatment systems prior to construction, operation, and discharge. Typically, these approvals are through the issuance of an MPDES permit. However, because sufficient information was not available to develop MPDES permit limits, DHES issued ZMI an Administrative Order on September 28, 1994 authorizing the construction and discharge from the Ruby Gulch water treatment plant. Interim effluent limits and monitoring requirements are contained in this order.

Regarding the Clean Water Act Section 401 (State Water Quality Certification for discharge to state waters), this certification can be based on state water quality standards or the state can conditionally waive standards.

In June 1995, the EPA filed suit against ZMI alleging violations of the Clean Water Act at drainages impacted by mining operations.

During 1995 and early 1996, EPA, DEQ, and ZMI continued detailed negotiations regarding a compliance plan and consent decree to address the above issues.

Open Cut Permit

DEQ, under 82-4-422 *et seq.*, MCA, issues another permit regarding open cut mines for shale, clay, and other industrial minerals extraction. For the Zortman and Landusky mines, amendments to the permit are in process to address the old and new Williams and

Seaford clay pits. A reclamation bond and plan are required.

Air Quality Permit

The DEQ administers the Montana Clean Air Act. Any proposed project with estimated pollutant emissions (without emissions controls) exceeding 25 tons per year must obtain an air quality permit before commencement of construction. The applicant must apply Best Available Control Technology (BACT) to each emission source and demonstrate that the project would not violate Montana or Federal Ambient Air Quality Standards. ZMI has separate air permits for the existing Zortman and Landusky mines which would require modification to implement the mine extension alternatives.

An air quality permit alteration (modification) was submitted in October 1994 to DEQ, for the Zortman extension, or the Company Proposed Action at the Zortman Mine only (MDHES-AQD 1994a). The permit was deemed procedurally complete.

1.5.2 Bureau of Land Management

Under the United States mining laws, claimants and operators have been authorized to develop locatable mineral resources on public lands that are open to operation of the Mining Law. Once unpatented mining claims are staked the claiment is obligated to perfect (develop) these claims. The majority of the BLM lands in the Little Rocky Mountains are open to operation of the Mining Law in conformance with the Judith-Valley-Phillips Resource Management Plan EIS (BLM 1992a; see pp. 10, 11, 88, and 89).

Section 302(b) of the Federal Land Policy and Management Act of 1976 (FLPMA) directed the Secretary of the Interior to: "by regulation, or otherwise, take any action necessary to prevent unnecessary or undue degradation of the lands." In 1981 the BLM promulgated regulations under Title 43, Code of Federal Regulations, Part 3809, to implement the FLPMA requirements for mining activities on BLM-administered lands. These "3809" regulations detail the requirements for approving a Plan of Operations, or a significant modification to an already approved Plan of Operations, which is the case for the Zortman and Landusky mines. BLM must review the operator's proposed Plan of Operations to determine whether it would result in unnecessary or undue degradation of the federal lands. Measures needed to prevent unnecessary or undue degradation are required as conditions of approval.

Unnecessary or undue degradation was not defined in FLPMA, but is defined in the BLM regulations at 43 CFR 3809.0-5(k); and briefly means: (1) surface disturbance greater than what would normally result when activity is being accomplished by a prudent operator; (2) failure to take into consideration the effects of operations on other resources and land uses; (3) failure to initiate and complete reasonable mitigating measures, including reclamation; and (4) failure to comply with applicable environmental statutes and regulations. If it is determined that the action would not cause unnecessary or undue degradation, then BLM is required to approve a Plan of Operations for lands open to mineral entry. A final determination as to the adequacy of the proposed mine plan, or a preferred alternative, in preventing unnecessary or undue degradation will be made in a Record of Decision. This will be based on the impacts identified during the EIS process and the requirements of the 3809 regulations.

While approval of a Plan of Operations that does not cause unnecessary or undue degradation is non-discretionary (i.e., BLM must approve such a plan), it is a federal action which must be analyzed under NEPA. The approval of the Plan of Operations by BLM only applies to BLM lands; however, NEPA requires that the environmental analysis address impacts of the approval on both private and public lands.

In addition to FLPMA and the 1872 Mining Law, there are several other acts that direct management of public mineral resources. These are the 1970 Mining and Mineral Policy Act and the 1980 Natural Materials and Minerals Policy, Research and Development Act. Both of these acts direct that the public lands be managed in a manner which recognizes the Nation's need for domestic sources of minerals production.

The BLM also administers the sale and removal of mineral materials such as sand, gravel, and other industrial minerals under the Materials Act of 1947 and the Surface Resources Act of 1955. Limestone proposed to be mined from public lands for use in reclamation capping and drainage construction would require a separate mineral material sale contract to be issued in accordance with BLM regulations at 43 CFR 3610. These regulations include requirements for reclamation of the quarries and posting of a performance bond. This EIS will serve as the NEPA document for limestone mining associated with the Zortman and Landusky Mines.

The BLM's 3809 regulations provide that the Authorized Officer may require the operator to furnish a bond to ensure that the reclamation is completed. The reclamation bond is an enforcement tool used to ensure

that the approved reclamation plan would be implemented should the operator be unable or unwilling to do so. As such, the reclamation bond is based on the reclamation plan.

In Montana, DEQ's Hard Rock Bureau has similar authority. By Memorandum of Understanding reclamation bonds for hardrock mining are held by the State of Montana on behalf of both BLM and DEQ. This is done to prevent "double-bonding" for the same disturbance since both agencies' regulations require reclamation bonding. Prior to final release of project reclamation bonds, BLM and DEQ will further require a site investigation to prevent future releases of hazardous materials remaining on site (see Sections 3.14 and 4.14).

Also, prior to approving a Plan of Operations, BLM must comply with Section 106 of the National Historic Preservation Act (NHPA), as amended. Section 106 of the NHPA does not prevent or prohibit the disturbance of historic properties by a federal action, but it does require specific steps to be taken by the federal agency before approving such an action. In brief, compliance with the NHPA involves four basic steps: (1) identifying historic properties which might be affected; (2) assessing the effects to those properties; (3) consultation with the State Historic Preservation Officer (SHPO) and interested parties; and (4) comment by the Advisory Council on Historic Preservation if historic properties will be affected.

The American Indian Religious Freedom Act (AIRFA) was passed as a joint resolution of Congress and has no implementing regulations. The resolution states that it shall be the policy of the United States to protect and preserve for the American Indian the inherent right of freedom to believe, express, and exercise their traditional religions, including, but not limited to access to religious sites, use and possession of sacred objects, and freedom to worship through ceremonies and traditional rites. BLM complies with this act by seeking and considering the views of Native American traditional leaders when a proposed land use might conflict with traditional Native American religious beliefs or practices.

Another act which BLM must consider in its decision making is the Religious Freedom Restoration Act of 1993 (RFRA). This law restores the compelling interest test as set forth in Sherbert v. Verner, 374 U.S. 398 (1963) and Wisconsin v. Yoder, 406 U.S. 205 (1975), that requires government (federal or state) to demonstrate a compelling government interest before substantially burdening a person's religious liberty. In brief the law states:

> *Government may substantially burden a person's exercise of religion only if it demonstrates that application of the burden to the person:*
> *(1) is in furtherance of a compelling government interest; and*
> *(2) is the least restrictive means of furthering that compelling government interest.*

This Act does not impose specific procedural requirements. However, it does restore a powerful standard for justifying governmental burdens on religious liberty, affecting all persons and all religions equally.

1.5.3 Cooperating and Coordinating Agencies

While DEQ and BLM share overall EIS responsibility for this project, several other federal and state agencies, and local authorities, may require permits, approvals or licenses for the proposed project. The following sections summarize regulatory and permitting authority for these entities. Table 1-3 contains a list of the major permits, licenses and approvals that may be required by cooperating and coordinating agencies.

1.5.3.1 Cooperating Agencies

Two agencies are cooperating for this EIS pursuant to the Federal Council on Environmental Quality (CEQ) NEPA regulations at 40 CFR 1501.6. This regulation provides that the lead agency may request any other Federal agency to serve as a cooperating agency, if the agency has jurisdiction or special expertise regarding an environmental issue or issues that should be addressed in a NEPA document. Formal EIS cooperating agencies for the Zortman-Landusky mine extension are:

- U.S. Environmental Protection Agency (EPA)
- U.S. Army Corps of Engineers (COE)

A Memorandum of Understanding is in place to outline roles and responsibilities of the various cooperating agencies (DSL/BLM 1993b).

U.S. Environmental Protection Agency

Section 309 of the Clean Air Act provides the EPA with authority to review and comment on federal actions under NEPA. EPA reviewed the environmental analyses within the Draft EIS for compliance with NEPA requirements and guidelines of the CEQ. In addition, EPA has overall authority for specific permitting actions which may be required for the Zortman Mine expansion. For instance, although the

TABLE 1-3
MAJOR PERMITS, LICENSES, AND APPROVALS POTENTIALLY REQUIRED FOR THE ZORTMAN AND LANDUSKY MINE EXTENSIONS[1]

Agency	Permit, License or Review	Authority	Purpose/Status
Montana Department of Environmental Quality	• State Operating Permit (Metal Mine Reclamation Act)	Title 82, Chapter 4, Part 3, *et seq.*, MCA; ARM §26.4.101 *et seq.*	To allow mining while adequately providing for the subsequent beneficial use of the lands to be reclaimed. Approval is documented in a Record of Decision.
	- Reclamation Bond	§82-4-338, MCA	Required of Proponent to assure sufficient reclamation funding is available at mine closure or abandonment.
	- Monitoring Plans	§82-4-335(4)m, MCA	To assure compliance with state and federal environmental resource standards and criteria; coordinate with other governmental agencies.
	• Open Cut Permit	§82-4-422 *et seq.*, MCA	For excavation of shale and clay pits; includes reclamation plan and bond.
	• Montana Pollutant Discharge Elimination System Permit (MPDES)	ARM 16.20.1301 *et seq.*	To control discharge (including stormwater runoff) to surface waters by setting water quality limitations and requiring self-monitoring. Conditions for MPDES permits for Zortman and Landusky mines are under negotiation in 1996.
	• 401 Certification	Sec. 401, Federal Clean Water Act (33 USC 1341); Montana ARM 16.20.1701 *et seq.*	Required prior to the U.S. Corps of Engineers being able to issue a 404 Permit; and is applicable to all federal activities which result in a discharge to state waters.
	• Permit for Construction and Operation of Air Contaminant Source	Montana Clean Air Act, ARM §16.8.11 *et seq.*	To control emissions of more than 25 tons per year of particulate matter.

TABLE 1-3 - MAJOR PERMITS, LICENSES, AND APPROVALS (Continued)

Agency	Permit, License or Review	Authority	Purpose/Status
U.S. Bureau of Land Management[2]	• Approved Plan of Operations	43 CFR §3809	To allow for mineral exploration and development on U.S. lands administered by BLM. Approval incorporates management requirements to minimize or eliminate effects on other BLM resources. Approval is documented in a Record of Decision.
	- Monitoring Plans	43 CFR §3809	To assure compliance with state and federal environmental resource standards and criteria: coordinate with other governmental agencies.
	- Reclamation Plan	43 CFR §3809; BLM Solid Minerals Reclamation Handbook No. H-3042-1	In coordination with DEQ, to ensure all reclamation activities meet the guidelines in the Resource Management Plan and BLM Manual Section 3042.
	• Material Site Permit	43 CFR §3610; Mineral Material Regs.	Material sale contract to establish fair market value and reclamation procedures for limestone from proposed quarry.
U.S. Environmental Protection Agency	• Review and approval authority for various programs, including 404 permit	Section 309 of Clean Air Act; Clean Water Act; other environmental statutes	Various NEPA review, environmental enforcement and oversight authorities.
U.S. Army Corps of Engineers	• Section 404 Permit for placement of fill or dredged material in wetlands or waters of the U.S.	Section 404 of the Clean Water Act	To control discharge of dredged or fill material into waters or wetlands of the United States; including intermittent streams where a bed and bank are recognizable.
U.S. Fish & Wildlife Service	• Biological Assessment	Section 7, Endangered Species Act, Migratory Bird Act	For Endangered Species Act compliance. If it is determined that adverse effects would occur to threatened or endangered species as a result of the Zortman and Landusky Mine extensions, the lead agencies would consult with USFWS to determine if measures could be developed to protect the affected species.
Montana State Historic Preservation Office	• Review of project for compliance with regulations governing protection of cultural and historic resources	Section 106 of the National Historic Preservation Act; 36 CFR Part 800	If historical, archaeological, or other cultural resources are located in the project area, the State Historic Preservation Officer would advise the lead agencies on impact mitigation of sites eligible for nomination to the National Register of Historic Places.

TABLE 1-3 - MAJOR PERMITS, LICENSES, AND APPROVALS (Concluded)

Agency	Permit, License or Review	Authority	Purpose/Status
Montana Department of Natural Resources and Conservation	• Water Rights Permit	Montana Water Use Act, Title 85, Chapter 2, MCA	Required if the Proposed Action would use or extract, through surface water diversion or groundwater withdrawal, state water in an amount exceeding 100 gallons per minute.
Phillips County	• Floodplain Development Permit	Title 76, Chapter 6, Part 113, MCA	Required for construction of facilities within designated 100-year floodplains.
Montana Hard Rock Mining Impact Board and "Affected" Local Government Units	• Fiscal Impact Plan	Hard Rock Mining Impact Act: Title 90, Chapter 6, Parts 3-4, MCA	To mitigate fiscal impacts on local government services; (not required for ZMI extensions.)
Phillips County Conservation District	• 310 Permit	Natural Streambed and Land Preservation Act, Title 87, Chapter 5, Sections 501-509, MCA	For any activity that physically alters the bed or banks of a stream. MDFWP provides recommendations and consultation.

[1] Note: It is the responsibility of the operator to have knowledge of, and obtain, any federal, state or local permits, licenses, approvals or reviews required by such entities for construction, operation, or closure of these projects. This tables does not present an exhaustive list; several other actions will likely be required for project permitting. Expected hazardous materials for the Zortman/Landusky sites, including provisions for spills, are detailed in Sections 3.14 and 4.14.

[2] BLM, as the lead federal agency in the mine permitting action, and the steward for the federal lands impacted by the mining activities, would be responsible for ensuring that permitted actions comply with a number of federal statutes and regulations implementing those laws, including: the American Indian Religious Freedom Act (Public Law 95-341), the Archaeological Resources Protection Act (Public Law 96-95); the National Historic Preservation Act (Public Law 89-665); the Archaeological and Historic Preservation Act (Public Law 93-291); and the Endangered Species Act (Public Law 93-205).

COE has authority for Section 404 permits (described below), EPA has a statutory veto power over the COE decision.

EPA has authority for the NPDES program on the Fort Belknap Indian Reservation, should the proposed action or alternative actions require an NPDES discharge permit to streams on tribal land. The EPA also has oversight for, and has delegated authority to, issue NPDES permits in Montana, to DEQ. The EPA and DEQ, are taking joint actions to ensure compliance with the CWA and Montana WQA.

On June 5 1995, the EPA filed suit against ZMI in U.S. Federal District Court alleging violations of the Clean Water Act at drainages impacted by mining operations.

U.S. Army Corps of Engineers

ZMI would require a permit issued under Section 404 of the CWA if the proposed action requires the discharge of dredged or fill material within waters of the United States, including jurisdictional wetlands and intermittent streams where a bank and bed are recognizable. The COE has permitting authority for this program, and is an official cooperating agency for this EIS under CEQ regulations as well. The COE has determined that an individual permit is necessary to implement any of the various alternatives. Appendix B is the draft 404(b)(1) evaluation prepared by the lead agencies and reviewed by the COE.

To date, the COE has issued a permit for construction of two impoundments in Ruby Gulch that were designed to catch drainage from upper Ruby Gulch to enable treatment of such waters. Before a COE permit can be issued for a Zortman/Landusky expansion proposal that involves a discharge of dredged or fill material into jurisdictional waters, the COE must determine that the project will be in compliance with the 404(b)(1) guidelines, that the project will be found to be "in the public interest," and that 401 water quality certification is obtained.

In the 404 permit applications submitted to the COE, it is stated that the purpose of ZMI's proposed activities is to recover gold and silver from the existing Zortman and Landusky mines. Therefore, the basic project purpose is to mine gold and silver. In accordance with the Clean Water Act, the COE is required to consider and express in its NEPA document the activity's underlying project purpose from a public interest perspective. Thus, the underlying project purpose from a public interest perspective is to supply the public with needed gold and silver by mining in an environmentally sound manner.

The 401 State Water Quality Certification (see DEQ above) is required before the COE can issue a 404 permit. A 401 certification from DEQ would be issued if the discharge would not "adversely impact existing water quality" (COE 1995).

1.5.3.2 Coordinating Agencies

U.S. Fish & Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) administers the Endangered Species Act, the Migratory Bird Act, and the Bald Eagle Protection Act. To comply with the Endangered Species Act, BLM has prepared a Biological Assessment that was issued with the Draft EIS (Appendix C), to determine adverse impacts, if any, to threatened and endangered species. If adverse effects may occur, BLM will formally consult with the USFWS to design measures to protect the affected species. The Biological Assessment has been revised as final and is herein issued with the Final EIS (see Appendix C), incorporating comments from USFWS.

State Historic Preservation Office

Under the Montana Antiquities Act and the National Historic Preservation Act, the State Historic Preservation Office (SHPO) has the responsibility to cooperate with and to advise BLM and DEQ when potentially significant historical, archaeological, or other cultural resources are located in the project area. Part of the advice given may include plans for impact mitigation of sites eligible for the National Register of Historic Places. The SHPO and the Keeper of the National Register of Historic Places have reviewed issues regarding eligibility of the Little Rocky Mountains to the National Register, as a traditional cultural property district.

Montana Department of Natural Resources and Conservation

The Montana Department of Natural Resource and Conservation (DNRC) administers two acts that may be applicable to mining development in Montana: the Montana Major Facility Siting Act (MFSA) and the Montana Water Use Act. The MFSA requires state approval before construction of any electrical transmission line that exceeds 69 kV or 10 miles in length. A water rights permit is required by the Montana Water Use Act for any surface water diversion or a groundwater withdrawal exceeding 100 gallons per minute (see Chapter 2.0 for details regarding project engineering).

Phillips County
Phillips County has the option to review and issue a floodplain development permit pursuant to 76-1-113, MCA, for any activity that infringes on the 100-year floodplain of a perennial stream with County jurisdiction.

Phillips County Conservation District and Montana Department of Fish, Wildlife, and Parks
Any mining disturbance occurring within the normal high water level of streams inside or outside of BLM boundaries would require the approval of the Phillips County Conservation District. This approval would constitute a "310 permit" under the Natural Streambed and Land Preservation Act. Prior to granting approval, the District would consult with BLM and the Montana Department of Fish, Wildlife and Parks (MDFWP).

Hard Rock Mining Impact Board
The Hard Rock Mining Impact Act (Title 90, Chapter 6, Parts 3-4, MCA) was enacted in 1981 to assist local governments in handling financial impacts caused by large-scale mineral development projects. The legislature recognized that: (1) new mineral development projects may result in the need for local governments to provide additional services and facilities causing a fiscal burden for local taxpayers, before mine-related revenues become available; and (2) some local government units may lack jurisdiction to tax a new development.

ZMI is exempt from this requirement for both the Zortman and Landusky mines because the initial application for mine operations in 1979 pre-dated the law (Hard Rock Mining Impact Board 1995). However, social and economic impacts of the proposed action and alternatives are analyzed in this EIS (see Section 4.10).

Montana Department of Fish, Wildlife & Parks
Although the MDFWP has no statutory authority over mining in Montana, they do act in an advisory capacity to the local conservation districts, when such districts are processing Section 310 permits for developments by private individuals under the Montana Natural Streambed and Land Preservation Act (see previous discussion of Phillips County and MDFWP).

U.S. Bureau of Indian Affairs
The Bureau of Indian Affairs (BIA) is a commenting agency on the EIS. A BIA office is located on the Fort Belknap Indian Reservation.

Fort Belknap Indian Reservation
The Fort Belknap Community on the Reservation is a commenting agency on the EIS.

Blaine County
Blaine County has the option to review and issue a floodplain development permit pursuant to 76-1-113, MCA, for any activity that infringes on the 100-year floodplain of a perennial stream with county jurisdiction. This action is unlikely, since the proposed action and alternatives facilities are all in Phillips County.

Agency for Toxic Substances and Disease Registry
The Agency for Toxic Substances and Disease Registry (ATSDR) is a U.S. Public Health Service Agency, which was created by the Comprehensive Emergency Response, Compensation and Liability Act (CERCLA). The Agency's authorities were greatly expanded by the Superfund Amendments and Reauthorization Act (SARA). Since 1992, ATSDR has been involved, intermittently, with the public health issues related to mining in the Little Rocky Mountains. The result of ATSDR's early involvement was the development of three public health consultations which evaluated the public health threat associated with mine tailing located in the King Creek headwaters. More recently, ATSDR has received a petition to conduct a public health assessment (PHA) regarding the potential for residents of the Fort Belknap Indian Reservation to experience adverse health effects as a result of operations at the Zortman and Landusky mines. If a decision is made to conduct a PHA, or if additional health considerations are requested, ATSDR will continue to be actively involved with the public health issues associated with the Zortman and Landusky mines. Results of ATSDR studies to date are reported in Section 3.10.2.5.

1.6 STUDY AREA DEFINITION

The EIS study area is best represented geographically by the Little Rocky Mountains, in north central Montana. The proposed mining operations and areas of disturbance related to the mining (waste rock storage, leach pads, and related facilities) are within the Little Rocky Mountains. Most potential environmental impacts would thus occur to the air, waters, surface resources, or wildlife within the Little Rocky Mountains. However, impacts related to the proposed action and alternatives are not solely limited to the local area. As an example, impacts to wildlife within this area extend far from the mine site, since big game species may travel many miles between winter and summer feeding grounds, and bird species often migrate long distances. Impacts to sites in the Little Rocky Mountains that are

culturally important to Native Americans may be felt far from the project area, as some tribal members may travel long distances for plant gathering or spirit quests. Socioeconomic impacts are likely widespread, since many people who would continue to be employed at the Zortman and Landusky mines would commute from communities such as Malta. On the other hand, soil and vegetation impacts may be mostly confined to the Zortman and Landusky extension disturbance areas (Figures 1-2 through 1-4).

Political boundaries are also important. The Zortman and Landusky mines are located on the southwest portion of Phillips County, near the southern boundary of the Fort Belknap Indian Reservation. Various communities on and off the reservation would be impacted by jobs and revenues maintained by the mine extensions and reclamation, and by service demands for those workers and families and support personnel. Some communities near the mine site may be affected by environmental impacts to air, land, water and aesthetic resources. Nevertheless, for the purpose of defining the limits of the environment most likely to be impacted by expanded mining at the Zortman and Landusky mines, the study area is generally considered the Little Rocky Mountains but may vary according to each individual environmental resource.

1.7 ISSUES AND CONCERNS

Public participation is a key requirement of both MEPA and NEPA, and vital to development of alternatives and consideration of impacts in the EIS. The first opportunity for public involvement occurs in the beginning of the EIS process, when scoping is conducted. One purpose of scoping is to compile a list of environmental issues related to the proposed action, and to discuss the relative impact of these issues. The scope of this EIS was established by the agencies' understanding of the proposed action and technical concerns, as well as the issues identified through oral and written comments received from the public and commenting agencies.

To identify issues and concerns related to the proposed action, public scoping undertaken by BLM and DSL included:

- Summer 1992 - An attempt is made by BLM/DSL to form a citizens' advisory group on the Zortman Mine expansion EIS; this effort was unsuccessful due to federal administrative procedures.
- December 1992 - A public scoping meeting on the Zortman Mine expansion is held in Malta (Phillips County).
- December 1992 - A public scoping meeting on the Zortman Mine expansion is held in Dodson (Phillips County, near the Blaine County line).
- December 1992 - A public scoping meeting on the Zortman Mine expansion is held in Hays (on the Fort Belknap Indian Reservation in Blaine County).
- April 1993 - A follow-up public scoping meeting on the Zortman Mine expansion is held in Lodgepole (on the Fort Belknap Indian Reservation, in Blaine County).
- December 1993 - A public meeting is held in Dodson to receive comments on the Landusky ARD EA.
- December 1993 - A "Dear Reader" letter informs the public of scoping comments on the Zortman Mine expansion, and tentative alternatives to be addressed in the EIS.
- March 1994 - The Decision Record is sent to the mailing list of interested public and agencies regarding the Operating and Reclamation Plan modifications to control and remediate acid rock drainage at the Landusky Mine.
- April 1994 - A "Dear Reader" letter discusses inclusion of the Landusky Mine expansion within the scope of Zortman Mine EIS, and tentative alternatives to be evaluated in the EIS.
- April and July 1995 - Public meetings on a draft MOA for mitigation of impacts to cultural resources are held in Hays, Lodgepole and Landusky.
- August 1995 - The Draft EIS is mailed to the public.
- September 1995 - Public open houses/hearings on the Draft EIS are held in Lodgepole, Hays, Malta, Landusky, and Great Falls.

Comments, suggestions, and concerns about the project and associated EIS were gathered from the efforts above. In addition to the comments received at the public meetings, written comments were also received during the scoping process. A complete discussion of scoping concerns for both the Zortman and Landusky mine extensions is on file with DEQ in Helena, and with BLM in Lewistown and Malta (DSL/BLM 1993b; DSL/BLM 1994b). The issues and concerns raised by the public during scoping were used in the development of alternatives, and are addressed in the baseline and impacts analysis in this EIS. A summary of these issues

and concerns from both scoping and the Draft EIS review comments is presented in Table 1-4.

The issues in Table 1-4 have distinctly shaped the alternatives presented in Chapter 2.0. Alternatives to ZMI's proposed action have been further developed to address (1) environmental concerns raised by the public or commentors during the Zortman and Landusky scoping and Draft EIS review process, (2) environmental degradation that has already occurred at one or both of the mine projects, and (3) potential environmental or engineering problems that the agencies have identified during the completeness reviews of the proposed action. The significant issues that have influenced the alternatives development process are summarized below.

- Water Quality (groundwater and surface water) - Concern that existing and/or historic mining operations have impacted and are continuing to impact water quality (and therefore aquatic habitat) in the area has been frequently raised as an issue. Releases of acidic and metal-laden water from the mines have resulted in the loss of aquatic habitat and have adversely impacted the streams and ground water in the area, some have asserted. Cyanide and metals are mentioned most often as pollutants of concern.

- Traditional Cultural Properties - Areas within the Little Rocky Mountains, and specific sites near the Zortman and Landusky mines, are culturally and historically important to various North American Indian peoples. Many public comments received by the agencies during the scoping meetings and public hearings for the Draft EIS and previous mine permitting actions have expressed concerns about impacts to cultural resources resulting from mine actions.

- Mine Waste Geochemistry/Acid Rock Drainage - This issue is related to the water quality issues discussed above. Concern has been expressed that some of the existing mine, heap leach and waste rock facilities have acidified and are releasing dissolved metals to ground and surface waters. The proposed mine expansion would develop sulfide ore and waste to an extent not contemplated previously for this project, some have suggested. Concerns have been raised regarding both mitigation of existing impacts and possible additional adverse water quality impacts following mine expansion.

- Proposed Heap Leach Pad and Ponds - ZMI has proposed construction of an expanding pad and external solution ponds at the Goslin Flats site below the existing Zortman Mine facilities. Concerns about storage and potential leakage of process solution, visual impacts, access restrictions to the Saddle Butte and Azure Cave areas, effectiveness of heap neutralization prior to closure, heap stability, adequate solution storage and flood diversion, quality of construction, ARD potential and hazards to wildlife from stored process solution have been expressed.

- Pit Expansions - ZMI has proposed development of an expanded open pit operation that would deepen and widen the existing mine pit complexes at both the Zortman and Landusky operations. Concerns have been raised regarding visual impacts; contamination of water in pits and release of that water to surface drainages and groundwater; noise and vibration from blasting and equipment; and ARD and reclamation, including the potential to partially or totally backfill pits.

- Waste Rock Dump - Carter Gulch has been proposed by ZMI as the site of the new waste rock repository for the Zortman Mine. This location has been partially developed as a waste rock dump for existing operations but has sufficient capacity to contain waste rock generated by the proposed expansion. Concerns about waste characterization, waste handling, waste modification, acid rock drainage, dump stability, and reclamation and monitoring of dump performance have been raised.

- Reclamation Plans and Procedures - Some reclamation at the mines has proved to be inadequate and/or ineffective. For instance, ARD emanating from some heap leach facilities and waste rock dumps may be due to poor reclamation procedures, or a failure to use appropriate materials to prevent water infiltration into the acid-producing materials. ZMI has proposed various rock characterization methods, materials handling procedures, and engineering practices to enhance the potential for successful reclamation.

- Ore Conveyance System - ZMI has proposed to use an ore conveyor system to transport ore from the Zortman Mine pit complex to a proposed heap leach facility in Goslin Flats. Concerns have been raised about the environmental effects of this system, particularly generation and release of dust from an

TABLE 1-4
ISSUES AND CONCERNS

Resource Area	Summary of Issues & Concerns
Acid Rock Drainage	Leaching of acid and metals from mining; impacts of acid rock drainage (ARD) on water quality; adequacy of monitoring and reclamation plan to control ARD; required thickness and type of liner adequate to protect the environment; possibility of the degradation of all streams in the Little Rocky Mountains, such as Ruby Gulch, due to ARD; degradation of groundwater from exposed, sulfide-bearing ores and surface water infiltration through pit floors; MMRA compliance.
Water Resources	Existing and long-term impacts of mining on water quality and water supply; contamination of community water supplies; monitoring and testing of water quality; degradation of surface and ground water quality; cyanide contamination and containment; lack of data regarding groundwater movement in bedrock; degradation of groundwater and surface water resources north of the mines, on the Fort Belknap Indian Reservation; assumptions and appropriateness of HELP model to project impacts to water resources.
Cultural Resources	Little Rockies considered sacred mountains to the Native Americans; concern that numerous values are significantly altered by mining activities; concern that existing ethnographic studies and reports were not conducted appropriately, do not adequately express the opinions of Native Americans, do not examine all sacred areas, and exclude interviews with people who are concerned and/or use the area; concern that visual resources will be impacted when viewed from vision quest sites; mine expansion effects on Turtle Mountain lands; environmental justice; BLM trust responsibilities; compliance with Section 106 of the National Historic Preservation Act; aboriginal rights.
Geology	Proper procedures for drilling and exploration activities; impacts from use of limestone quarries; impacts of lime and other materials on water quality; protection of paleontological resources in the Little Rocky Mountains; adequate engineering of the pad and waste dumps; potential for failure of new and existing facilities geologic hazards; impacts of blasting on the Azure Cave geologic formations.
Soil & Reclamation	Adequacy of type, amount, and thickness of soil; slope steepness and stability; soil sampling; competence of shale liner at the heap leach pad; adequate monitoring and inspection of the reclamation plan; quality control of reclamation activities; plan's overall effectiveness and quality; efficacy of reclamation covers; documentation that water balance covers work and are applicable for proposed uses; inter-bench slopes and distance on reclaimed facilities; feasibility and cost of backfilling mine pits; reclamation of all ARD-causing exposures.

TABLE 1-4 - ISSUES AND CONCERNS (Continued)

Resource Area	Summary of Issues & Concerns
Land Use	Post-mining land use, based on the cumulative impact of current operations and the proposed expansion (i.e., post-reclamation use for heap leach pads); reduction of land available for recreational use; reduction of land available to Native Americans; impacts of mining activites on Trust lands; reduction of agricultural land use for expansion of mining activities; lack of access to mineral claims in Goslin Flats due to leach pad construction and use; public land vs. private property rights.
Wildlife	Wildlife protection; long-term effects of mining and chemicals on wildlife; species of concern, such as bats of Azure Cave (numbers and species), bighorn sheep, big game migration routes and corridors, and various birds, including piping plover nests in Phillips County; system of reporting wildlife mortalities to the public and the fencing/netting around ponds and other mine facilities; mitigations to replace lost wildlife habitat; conveyor corridor impacts on big-game movement.
Vegetation and Wetlands	Protection of Saddle Butte's rare plant communities recognized by Montana Natural Heritage Program; noxious weed management; need for local, weed-free revegetation seed stock; need to protect any threatened and endangered plants and/or native plants and berries used for medicine by Native Americans; lack of information and inventory of medicinal/cultural plants in study area; potential need for a riparian study of the area; impacts of historic and current mining on wetlands and waters of the U.S.; mitigations for loss or impact to waters of the U.S.; revegetation procedures and plant mixes; revegetation success requirements and predictions.
Recreation	Impacts of the mine expansion on recreational uses for the Little Rockies, particularly well water contamination at the campgrounds and reduced access to Saddle Butte, Azure Cave, Pony and Alder Gulches, and Beaver and Spring Creek for outdoor recreational activities; closing of public roads; post-reclamation uses for the mining areas; increases vs. reductions in post-mining recreation; affects to local economy.
Engineering	Need for adequate engineering of all facilities at the mine, particularly those with potential human health and environmental impacts (heap leach pad, solution collection ponds, and solution pipelines); potential for leakage of solution pipelines, particularly at off-pad locations, such as along conveyor; slope stability of new and reclaimed facilities; failure potential of existing facilities; Ruby Gulch tailing removal and liability; pit backfilling with non-oxide ore.

TABLE 1-4 - ISSUES AND CONCERNS
(Continued)

Resource Area	Summary of Issues & Concerns
Human Health Risk	Risks to human health (need for blood testing, heavy metal contamination, cyanide and lead in water); overall long-term health hazards to children and pets; need for investigations and monitoring of all spills and leaks; public notification of cleanup procedures; involvement of ATSDR; pollution of private and public water supplies; MSHA testing of metals and cyanide, and conclusions with regard to worker safety and public health; public health risks from airborne emissions of silica, metals and cyanide.
Roads & Transportation	Concern over limited access to portions of the Little Rocky Mountains; potential safety hazards to local residents, especially the dangers of haul trucks in populated areas; impacts on wildlife from mine trucks; noise and air quality degradation from truck hauling.
Air Quality & Noise	Fugitive emissions from mining operations; use of water and chemicals to suppress dust on haul roads; wind-blown pollutants from pads, ponds, and dumps; impacts from ore crushing process; noise impacts from heavy equipment, trucks, conveyor, and blasting, especially during the Native American Sundance ceremony; noise and air quality impacts from the mine on wildlife and birds; air quality effects of assay lab at Zortman; metals and cyanide emissions, and worker safety; compliance with the Clean Air Act and Montana regulations; loss of viewshed quality from mine emissions and impacts to Class I areas.
Social & Economic Values	Effects of both the proposed mine expansion and the No Action alternative on the economies of Phillips and Blaine Counties and the Fort Belknap Reservation; potential for Native American employment opportunities at the mine; effects of the expansion on community facilities and services (water supplies, roads, electrical power rates); potential effects on property values in the Zortman area; economic implications of the health effects of the existing mine; social and cultural values of the Little Rocky Mountains; short-term impacts of mine closure during EIS development.
Visual Resources	Visual impacts of the leach pad, conveyor, and waste dumps; overall aesthetics of the Little Rocky Mountains, including impact of mining and reclamation on the natural shape of the mountains and valleys, ability to restore mountains to original form, and disturbance and landscape changes from mine facilities; disruption of visibility by mine lights at night; effects of visual changes on Native American vision questing; modification of post-mine facilities to better blend into area topography and landscape.

TABLE 1-4 - ISSUES AND CONCERNS (Concluded)

Resource Area	Summary of Issues & Concerns
Environmental Policy and Planning	Comprehensive EIS is required by law; public involvement and the scoping process; objectivity of studies; completeness of data and the permit application; adequacy of past environmental and engineering work; agency coordination and attention to public and special interest group concerns; violations of current permit requirements; applicability of other laws and regulations to proposed mine expansion; timing of EIS and coordination with ongoing (water quality) lawsuits; reclamation bonding, and concerns over the inadequacy of the current reclamation bond; cumulative impacts of mining activity in the Little Rocky Mountains.
Alternatives	Concerns regarding possible alternatives to the proposed action; support for the No Action Alternative; various suggestions for modified designs or plans; concern that the agencies consider a range of alternatives in the EIS; complete backfilling of mine pits; cost-benefit analyses of alternatives and technologies; implementation of alternatives; interdependence of Decision Record and ongoing (water quality) lawsuit.

Sources: DSL/BLM 1993b; DSL/BLM 1994a; Draft EIS public comment.

uncovered conveyor, visual impacts, problems with access to hunting and recreation lands, and noise generated from the conveyor.

- Socioeconomics - The Zortman and Landusky mines have employed a large number of workers during the years 1979 through 1995. This employment represents a significant percentage of the total workforce in the surrounding region. A concern to many people is the socioeconomic impact that mine closure would have upon mine workers and the area's economic base.

- Environmental Monitoring Program - The scope and adequacy of the program in effect for environmental monitoring, particularly with respect to water quality and reclamation has been questioned.

1.8 ISSUES AND CONCERNS NOT ADDRESSED

Issues are often raised during scoping and Draft EIS review which may be related to the action under consideration, but which cannot be resolved through the EIS process. For example, agency funding is set through federal or state legislation, and concerns over the adequacy of agency funding must be dealt with through legislative actions. The EIS scope has been established using the assumptions that the regulations relative to environmental standards are valid, that agency funding is determined by the legislative bodies, that the Mining Law applies, and that the lands are available for mineral development consistent with the land use plan for this region. The decision before the agencies, and therefore the EIS analysis, is focused on how to correct environmental problems from existing operations and how to condition future operations so that they comply with the applicable environmental laws and regulations.

A summary of these issues and the reasons they were not addressed, is as follows.

- Funding for Reservation water quality monitoring program - Funding is set by the appropriations process and is outside the scope of the EIS. The technical adequacy and monitoring needs relevant to the proposed action and alternatives has been addressed in the EIS.

- Violations of Grinnell Agreement - Resolving treaty disputes is outside the scope of the EIS process. The EIS analyzes and discloses impacts to those resources of concern to Native Americans such as wildlife, traditional use plants, timber, and water resources. However, evaluating whether those resources are covered by the Grinnell Agreement or any other treaty, or whether impacts to those resources violate specific treaty rights, is beyond the scope of the analysis. Should a mine Plan of Operations or Operating Permit be approved, it does not convey title or rights to any property or resources, and could not change any treaty rights.

- Loss of private citizens' rights to develop mineral rights in vicinity of Goslin Flats leach pad (placer gold claims) - These are mineral law and property rights issues which need to be resolved in the courts. The impacts to the mineral resources are within the scope and have been addressed.

- Adequacy of existing EPA standards for cyanide - This issue is beyond the technical scope of this NEPA analysis. Water quality standards are established by EPA in separate rulemaking procedures.

- Management of mining wastes as hazardous wastes - Establishing regulations specific to management of mine waste is a separate rulemaking process. The EIS does propose and evaluate alternate mitigation techniques to address management of mine waste at this site. Large-volume, low-toxicity, extraction and beneficiation (mining) wastes at the Zortman and Landusky mines are excluded from RCRA regulation under the Bevill amendment.

- Adequacy of agency staffing and monitoring to address potential violations - This is a Federal and State agency budget and administrative issue, subject to review and correction by executive, legislative, and judicial processes. Agency regulatory costs are outside the scope of the EIS process.

- Actual "value" of mineral deposit when factoring in necessary environmental protection costs - The permit decision will be based upon the requirement to prevent/correct *unnecessary or undue degradation* and to achieve successful reclamation; and not on how much profit the operator would make. If the operator feels that meeting these requirements would cost too much, then they have the option of not proceeding with the project. While the EIS does disclose potential socioeconomic, environmental and cultural impacts of mining, it would be extremely subjective to attempt quantifying the monetary benefits of gold mining versus the cultural and environmental costs. These are value judgements that individuals must make for themselves based on the information presented in

the EIS. The lands involved in the existing/proposed mining are either private lands or public lands administered by the BLM and open to mineral entry. The weighing of the merits and drawbacks of the various alternatives need not be displayed in a monetary nalaysis and should not when there are important qualitative considerations (40 CFR § 1502.25). The analysis assumes that the reclamation plans under the various alternatives would be implemented as described. Financial assurances (reclamation bonds) are required to ensure that this occurs and the reclamation cost is not shifted to the public. Please see Section 1.5.2 of the EIS for an explanation of the regulatory authority and responsibilities.

- Water rights - Adjudicating water rights is outside the scope of the EIS process for this action. The EIS does assess potential impacts to water quantity under the various alternatives. However, whether the impact to water quantity violates specific water rights is outside the scope of this EIS to determine. Should an amended Operating Permit or Plan of Operations be approved, it does not negate the legal requirement for ZMI to obtain water rights necessary for water use.

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CHAPTER 2.0
PROPOSED ACTION AND ALTERNATIVES

SUMMARY OF THIS CHAPTER

Chapter 2.0 describes the proposed mine life extensions and revised reclamation plans for the Zortman and Landusky mines. It also describes and summarizes the results of the process used to develop alternatives for the proposed mine expansions and reclamation procedures. The development, evaluation, and selection of project alternatives are necessary and vital parts of the environmental impacts evaluation process as defined in the National Environmental Policy Act (NEPA) and the Montana Environmental Policy Act (MEPA). As described in the regulations for implementing NEPA, the goal of this process is to "present the environmental impacts of the proposal and the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decision maker and the public (40 CFR §1502.14)." The process used in reaching a decision point includes:

- Evaluation of all reasonable alternatives including the No Action Alternative,
- Discussion of reasons for eliminated alternatives, and
- Evaluation of appropriate mitigation measures.

Included with the descriptions of alternatives in this chapter are activities considered to be "reasonably foreseeable future actions." These are actions which could be submitted to the agencies at some future time for review and approval. These are not specific proposals, but merely actions or trends that are reasonable to anticipate under the various alternatives considered in this Final Environmental Impact Statement (Final EIS) for the purpose of assessing cumulative impacts. As such, they can only be analyzed at a relatively general level. To implement one or more of these reasonably foreseeable future actions, Zortman Mining, Inc. (ZMI) (or some other operator) would have to submit a specific proposal with additional detail for agency review and MEPA/NEPA analysis.

Although the Zortman and Landusky mines are operating under separate mine permits, this Final EIS provides a comprehensive analysis of proposed additional mining and modifications of reclamation procedures at both mines. The Bureau of Land Management (BLM) and Montana Department of Environmental Quality (DEQ) decided to combine the environmental analysis for these mines because of their similarity in operations and environmental concerns, proximity within the Little Rocky Mountains, common mine operator, and the potential for each mine to contribute to cumulative environmental impacts. The agencies determined that the proposed modifications for the Zortman and Landusky mines should be reviewed in one comprehensive, environmental impact statement. For similar reasons, the U.S. Army Corp of Engineers has decided to review ZMI's 404(b)(1) Landusky Mine and Zortman Mine permit applications as one inseparable project. Based on the information submitted by ZMI, comments received during the scoping process, and comments received on the Draft EIS, the DEQ and BLM developed and refined a range of alternatives for evaluation in detail in the Final EIS. Chapter 2.0 has been organized to present the reader with the following:

- Section 2.1 describes the connection between the significant environmental issues associated with proposed future actions at the two mines, and the formulation of alternatives to address these issues,
- Section 2.2 describes the various alternatives to the proposed action, including those the agencies initially considered but later eliminated, along with the justifications for their dismissal from further evaluation,
- Section 2.3 summarizes the environmental impacts associated with each of the seven alternatives,
- Section 2.4 discusses implementation options and identifies the alternative preferred by the BLM and the DEQ, and
- Sections 2.5 through 2.11 provide complete descriptions of each of the seven alternatives.

2.1 SIGNIFICANT ISSUES

There are countless possible variations or alternatives to any proposed action. However, the purpose of developing alternative actions is to address issues, concerns, and potential problems created by the proposed action. This section describes how certain significant issues, that were identified in Section 1.7 as within the scope of the EIS, drove the formulation of alternatives.

• Water Quality - The public and commenting agencies have expressed great concern over the existing and potential future water quality problems at the mines, and the ongoing litigation to enforce compliance with the Montana Water Quality Act and the Federal Clean Water Act. Compliance with these acts is a statutory requirement under any alternatives that are developed. This requirement exists independent of the EIS process. However, there are different approaches that may be taken to achieve compliance, and these form the basis for alternative development.

The main water quality issue is degradation caused by acid rock drainage (ARD). There are two general approaches to mitigating ARD; these are: (1) control of the acid generation process, by preventing the generation of acid entirely or reducing the amount of acid generation, and (2) the collection and treatment of acid drainage. The first approach is termed "source control." The second approach is called "capture and treatment" or "active treatment." Alternative degrees of reliance upon either source control, active treatment, or an optimum combination of the two, were considered. Different methods for the classification of mine material as to its acid generation potential, sorting and placement of this material, management of run-on and run-off waters, type of reclamation cover and the location and design of water capture and treatment facilities were all factors considered in alternative development.

Source control alternatives for both existing and proposed mine facilities have been included. This involved considering alternative locations for waste rock or ore processing where water management would be more effective. Also considered are removal of all or portions of existing mine waste units that are causing or have caused water contamination, or with a high potential to cause contamination. Various options were considered for routing of storm water to avoid mine facilities with acid generating potential and to restore flow in drainages affected by a loss of recharge area.

Alternatives considered for water capture and treatment include the sizing of capture and treatment facilities for specific runoff events, location and redundancy of capture structures, and location of water treatment plants.

• Soil and Reclamation - Existing reclamation plans have been determined to be inadequate for materials with acid-generating potential. One requirement of the alternatives development is to consider possible different reclamation covers and slope configurations that will result in successful reestablishment of vegetation and limit surface water infiltration that could lead to the formation of acidic leachate.

Criteria establishing minimum successful performance for reclamation covers have been developed. These include limiting long-term soil loss to less than 2 tons per acre per year, achieving a stable vegetative cover density of at least 90 percent that of adjacent undisturbed lands, and limiting precipitation and surface water infiltration through the covers. Various reclamation cover designs have been identified for comparison to these criteria. These include the covers currently used at the two mines, alternative reclamation covers proposed by ZMI, and use of several different modified covers.

Various sources of material needed for construction of the reclamation covers were considered in development of specific alternatives. Different geochemical criteria needed for identification and classification of materials suitable for reclamation are evaluated in the alternatives.

Pit reclamation is a significant issue. A number of pit reclamation scenarios are evaluated, from complete pit backfilling (see Section 2.2.5) to reclaiming the existing pits in their current configurations. Pit backfilling was included in an alternative to the extent it mitigated or alleviated other environmental issues, such as the need to dispose of mine materials, the need to direct runoff away from the pit areas, the need to cover potentially acid generating surfaces, and the need to mitigate visual or aesthetic impacts.

• Wildlife - Significant wildlife issues include possible impacts to the bats of Azure Cave, wildlife mortality from mine process solutions, disruption of big game migration routes, and loss of habitat.

Alternatives that avoid the Azure Cave area have been formulated. These included a mine-expansion alternative (Alternative 5) that places the ore leaching facility away from the Goslin Flats area. This alternative also eliminates the need for a conveyor system for waste and ore transport, thereby addressing concerns over possible disruption of Bighorn Sheep migration by the conveyor.

Other alternative mitigation is considered such as replacement of what may be a primary wildlife water source that would be disturbed by leaching on Goslin Flats, and use of improved barriers that restrict access of wildlife to leaching solutions.

A limiting factor for big game species in the Little Rocky Mountains is the lack of open parks and meadows. Alternative reclamation plans which develop open space and meadows in a post-mining environment are included.

- Wetlands - Issues regarding past, present and possible future impacts to wetlands and non-wetland waters of the U.S. have been used to develop the alternatives. Alternatives that incorporate replacement of wetlands in the Goslin Flats area at various locations are considered, as are alternatives that avoid further wetland disturbance. Alternatives that involve restoration of areas impacted by historic mining, as compensation for current mine impacts to waters of the U.S., are included. Various approaches to improving water quality to address indirect impacts to wetlands and non-wetland waters of the U.S. are included in the alternatives.

- Native American Traditional Cultural Values - Issues related to Native American traditional cultural values include the effects on the Little Rocky Mountains, which are currently eligible for listing on the National Register of Historic Places as a Traditional Cultural Property. In addition, many Native Americans regard the Little Rocky Mountains as sacred. Practices such as vision questing, sundances and gathering of traditional plants occur in the range. On-the-ground inventory and consultation with Native Americans did not reveal any specific religious sites or gathering areas that would be directly impacted by the proposed action. Still, the Little Rocky Mountains are sacred, and any mining activity in this area is regarded by Native Americans as desecration which cannot be mitigated.

In response to this issue, non-expansion alternatives have been formulated. These alternatives, including the mandatory No Action Alternative, consider various approaches to final reclamation of existing mine facilities without permitting additional mining.

The Native American position leaves little, if any, options for development of mine expansion alternatives that would satisfy traditional, spiritual concerns. However, alternatives which mitigate indirect impacts of mine expansion on locations of traditional cultural importance are considered. In addition, alternatives which reduce impacts to environmental resources such as air quality, water quality, vegetation and wildlife that contribute to the sacredness of the Little Rocky Mountains are considered in the mitigated expansion alternatives. A Programmatic Agreement under Section 106 of the National Historic Preservation Act has been developed that includes measures to mitigate impacts to the Traditional Cultural Property by preservation of historic and traditional associations through recordation. This mitigation is part of the various mine expansion alternatives (see Appendix E).

- Social and Economic Considerations - Concerns expressed by the public over both the environmental degradation and the economic benefits from mining have played an important role in the development of alternatives.

Alternatives have been formulated that involve no additional mining and that focus on reclaiming the existing impacts of mining in the Little Rocky Mountains. These alternatives attempt to address the concerns of those who feel that the environmental effects of mining at the Zortman and Landusky mines are not acceptable.

Conversely, alternatives which provide for continued, or expanded mining have been formulated. These address the concerns of those who feel that the environmental impacts of mining are acceptable in exchange for the economic benefits.

Lastly, there are alternatives which attempt to balance mineral development needs with environmental protection needs. These alternatives involve some of the more intensive applications of mitigating measures, yet still allow continued mining. These include alternative facilities locations, improved plans for reclamation, reclamation performance criteria, off-site mitigation, enhanced water management, and other mitigating measures. These alternatives would address the concerns of those who feel that the economic benefits of mining should be obtained provided that strict consideration is given to other resource values.

2.2 DEVELOPMENT OF ALTERNATIVES

Reasonable alternative actions pertaining to the proposed Zortman and Landusky mine expansions were evaluated based on engineering, environmental, and economic factors. The engineering evaluation included technical implementability and effectiveness, while the environmental evaluation considered potential impacts to the environmental media of air, water, and soil with consideration of subsequent impacts to vegetation, wildlife, and human health. Cost was considered a factor in eliminating an alternative or mine modification only if the alternative or modification would result in an uneconomic mine project. Alternative locations were

considered regarding the waste rock storage facility sites, and the location for the ore heap leaching facilities, the two major facility components of the Zortman and Landusky mines. The following sections describe considerations evaluated in developing alternative sites for these facilities. Section 2.2.6 and Table 2.2-1 provide a summary of all alternatives considered and either eliminated or retained for further evaluation.

Public comment on the Draft EIS has suggested that other ore deposits should or could be considered as alternative mining locations. Mining another ore deposit, instead of the Zortman and Landusky deposit, is not a reasonable alternative. While ZMI has gathered substantial geologic data in connection with its properties in the Little Rocky Mountains, and has identified mineralization in the Pony Gulch area as discussed under reasonably foreseeable future actions, ZMI's exploration efforts have not identified additional deposits which could be considered as reasonable alternatives to development of the deposits at Zortman and Landusky. Evaluation of alternate mining locations where another ore deposit could be developed is not feasible or relevant to this NEPA analysis. Locations for mining mineral deposits are individually discovered after an extensive exploration program. Economically developable gold deposits are a rare discovery and the proposed mine expansions by ZMI has been designed for development of these particular deposits, with their specific geochemical characteristics and engineering requirements. An alternative site location for ZMI's proposal is not physically possible and could not practically achieve the objective of their proposal, which is to extract gold from specific ore deposits.

An alternative to mine only a portion of the known ore body, instead of mining all the ore, is also not a reasonable alternative. The scope of the EIS is the proposed action to mine 80 million tons of ore at the Zortman Mine and 7.6 million tons of ore at the Landusky Mine, along with reclamation at both mines. The expansions are designed to recover the known mineral resources and an arbitrary change to a smaller design would not provide for the most efficient recovery of the mineral resources, nor would it mitigate environmental impacts or lessen potential for future environmental degradation. Mining a lesser amount would not meet the purpose and need for the project. Such an alternative would be incomplete or a "piecemeal" approach to approving mine expansion, since it is likely the operator would apply for approval to mine the remaining ore at a future time, anyway.

The public has commented that resolving the current compliance charges prior to allowing any additional mining needs to be considered as a separate alternative. While this concern is understandable, it does not constitute a separate design or mitigation alternative that would change the impact assessment. Performance of imposed mitigation must be assumed to assess the impacts of an alternative. The comment would enforce a phased implementation approach to assure mitigation performance, but any alternative developed that allows additional mining would have the option to be implemented in this manner. A separate alternative is not necessary.

2.2.1 Zortman Waste Rock Storage Area

Selection criteria used to identify potential waste rock storage areas included, (1) sufficient capacity to accept 60 to 80 million tons of waste rock, (2) adequate subsurface and near subsurface foundation conditions, and (3) minimization of seepage potential (i.e., surface water, groundwater, and infiltration considerations).

ZMI's proposed waste rock storage facility (the Carter Gulch Waste Rock Repository) would be located in Carter Gulch, a side drainage of Alder Gulch (Section 2.8.1.5). This site has sufficient volume to store all waste rock generated during mining of the proposed Zortman Mine expansion. Additionally, geotechnical studies indicate that subsurface conditions at the site are suitable to allow the storage facility to be constructed, operated, and reclaimed.

Several other alternatives met the basic criteria for the waste rock storage area and were either considered and eliminated or included as alternatives described in Sections 2.5 through 2.11. These were: (1) Ruby Gulch (Upper), (2) Ruby Gulch (Lower), (3) Total or Partial Backfill of Zortman or Landusky Pits, (4) Goslin Flats, (5) Ruby Flats, and (6) Lodgepole Creek. These six alternatives are discussed below:

- *Upper Ruby Gulch* - Based on a review of the alternatives considered, Upper Ruby Gulch offers the advantage of a slightly smaller catchment area than the proposed Carter Gulch, and a location within already disturbed areas near the mine site. However, this location is in a large drainage area and acceptable water control and handling methods could not be developed. In addition, visual impacts associated with construction and operation of a required haul road across Shell Butte offsets potential advantages of the Upper Ruby Gulch alternative.

- *Lower Ruby Gulch* - Hydrological disadvantages, primarily from large base flows, difficulty with interception of upgradient runoff, and high potential for lateral infiltration into the waste rock facility,

combined with close proximity to the town of Zortman, made the Lower Ruby Gulch a less desirable alternative.

- *Zortman and/or Landusky Pits* - An economic screening of the project on the feasibility of backfilling the mine pits using waste rock was conducted (see Section 2.2.5). As a result of this analysis, partial backfilling of the pits has been considered and incorporated into Alternatives 3, 5, 6, and 7. The Company Proposed Action (Alternative 4) also incorporates partial pit backfilling.

- *Goslin Flats* - Goslin Flats was determined to be an unsuitable site for a waste rock repository because insufficient capacity would be available without developing multiple waste rock disposal units or filling in Ruby Creek.

- *Ruby Flats* - Ruby Flats just to the east of the Goslin Flats has the capacity for a contiguous waste rock repository, and this site has been incorporated into Alternative 6.

- *Lodgepole Creek* - The Lodgepole Creek site was eliminated from further consideration due to a larger catchment area than the proposed Carter Gulch, and the fact that this area is relatively undisturbed and upgradient of the Fort Belknap Reservation.

- *Waste rock on existing facilities* - The area currently occupied by existing Zortman Mine facilities satisfies the three waste rock location selection criteria, namely: sufficient capacity, adequate foundation conditions, and seepage minimization potential. It has been included for analysis in Alternative 7.

2.2.2 Landusky Waste Rock Storage Area

Similar selection criteria were considered for development of waste rock storage alternatives at the Landusky mine:

- *Gold Bug Waste Rock Repository* - The proposed alternative for waste rock storage involves placement of the waste rock in the existing repository or backfilled in other Landusky pits. This site is currently permitted and provides sufficient capacity for the anticipated volume of material under the proposed mine expansion (about 7.0 million tons of waste rock). Furthermore, additional disturbance would be minimized by using an existing facility such as the Gold Bug Pit, and double handling of waste rock would be minimized.

- *Zortman Pit* - An additional waste rock storage alternative considered was total or partial backfill of the Zortman Pits using waste rock from the Landusky Mine. This option was eliminated from further consideration because of the long haul distance and potential interference with the Zortman Mine operations.

2.2.3 Zortman Heap Leach Area

Selection criteria used to identify potential heap leach pad areas as alternatives to the proposed Goslin Flats site included (1) sufficient capacity, (2) suitable foundation conditions and slopes, and (3) minimization of potential infiltration and seepage.

The heap leach facility proposed by ZMI would be located at Goslin Flats, approximately three miles southeast of the Zortman Mine pit complex. This site is proposed because it has sufficient volume available for placement of all ore from the proposed Zortman pit expansion. Geotechnical studies indicate that subsurface conditions at the site are suitable to allow the heap leach facility to be constructed, operated, and reclaimed (Golder 1993). Additionally, this site would provide the necessary volumes of coversoil for the proposed reclamation plan.

Additional alternatives meeting the basic criteria for a heap leach facility that were considered and eliminated, or included as part of the alternatives discussed in Sections 2.5 through 2.11, are:

- *Ruby Gulch* - Ruby Gulch has slightly less catchment area than the Goslin Flats site. However, the reduced catchment area is offset by the disadvantages of requiring fill prior to pad construction, the problems associated with the interception of upgradient run-on, the high potential for lateral infiltration into the facility, and the proximity to the town of Zortman. As a result, the Ruby Gulch site was eliminated from further consideration.

- *Alder Gulch* - The Alder Gulch location is proximal to mine facilities and provides sufficient area for the pad, process facilities, and ponds. This site is considered as part of Alternative 5 (Section 2.9).

- *Lodgepole Creek* - The Lodgepole Creek site was considered and eliminated based on the relatively undisturbed nature of the drainage and its location upgradient of the Fort Belknap Reservation.

- *Existing Leach Pads* - Lack of sufficient capacity made the placement of ore on the existing Zortman and/or Landusky leach pads unacceptable.

- *In-Pit Leaching* - In-pit leaching at the existing Zortman and/or Landusky pits was considered and eliminated due to operational interference with proposed pit development.

2.2.4 Landusky Heap Leach Area

Similar selection criteria to that of the Zortman area were considered for the alternative evaluation for a heap leach facility in the Landusky area. The proposed action includes expansion of the existing 1987-1991 pad. This site is proposed based on its sufficient capacity with limited additional disturbance.

Additional alternatives were considered for a heap leach facility and eliminated. These included:

- *1985-1986 Pad Expansion* - This plan was eliminated based on proximity to Montana Gulch stream flows and concern over additional surface water degradation.

- *In-pit Leaching Zortman/Landusky* - These scenarios were eliminated based on operational interference with proposed pit development.

- *Existing Zortman Pads* - These were eliminated from consideration because they are at capacity.

2.2.5 Mine Pit Backfilling

An economic screening of costs associated with mine pit backfilling was performed to determine the range of alternatives available to address the significant issues (Haight 1996). A backfill alternative was considered unreasonable and eliminated from detailed impact analyses where it increased operating cost to the point that the overall feasibility of the mining project was doubtful.

The following conclusions regarding feasibility of potential backfill alternatives have been made based on the cost screening:

1. Alternatives which require complete backfilling of the Zortman and Landusky pit complexes to near the pre-mining configuration result in a non-viable mining operation, and are therefore not reasonable alternatives suitable for detailed analysis. Nor are such alternatives necessary to meet the primary environmental performance objectives.

2. Costs associated with backfilling of the mine pits with spent ore roughly equal or exceed the potential profits obtainable by mining and processing the ore. Alternatives requiring the ore to be placed back in the pits after leaching would render the project uneconomic (equivalent to a non-expansion alternative) even under a best case scenario that considers a leach pad site in close proximity to the mine pits.

3. The cost of backfilling the mine pits with waste rock consumes revenues from a commensurate amount of ore where double handling of the waste rock is necessary. Alternatives requiring backfilling of mine pits with waste rock are viable if they do not involve double handling of waste rock in amounts representing a substantial percentage of the ore tonnage. Alternatives that require all waste rock to be placed in the mine pits would make the mining project non-viable and therefore are not considered reasonable alternatives.

4. Partial backfilling of mine pits with waste rock would <u>not</u> make the mining project non-viable if material did not require double handling, or if the double handled material was in very close proximity to the backfill locations.

Partial backfilling alternatives are therefore considered reasonable and have been incorporated into Alternatives 3, 5, 6, and 7 where needed to meet environmental performance objectives. The Company Proposed Action (Alternative 4) also includes partial pit backfilling.

Partial pit backfill alternatives are adequate to meet the legal requirements of the Federal Land Policy Management Act, the Montana Metal Mine Reclamation Act, and to achieve the environmental performance objectives. The analysis presented in Chapter 4 shows that protection of water quality and successful revegetation can be achieved without pit backfilling beyond that needed to provide a free-draining surface suitable for reclamation cover placement.

2.2.6 Summary of Alternative Actions Considered

In addition to the two major facility components discussed above, other alternatives were considered for incorporation into an agency-modified alternative. These included mining methods, reclamation, ore transport, beneficiation technology, conveyor route, process solution storage, heap leach type, processing, waste rock transport, and water control. Alternative actions to be evaluated, and those eliminated from further consideration in this Final EIS, are summarized

in Table 2.2-1. The alternative actions shown in this table were developed by considering and evaluating:

- Company Proposed Action (CPA);
- Agency comments on the CPA, generated during completeness reviews;
- Public comments about the proposed extension and reclamation projects, solicited during scoping meetings, and hearings on the Draft EIS;
- Experiences at other mining projects;
- Technical literature and the relevant scientific database; and
- Past and present environmental concerns at the Zortman and Landusky mines.

The alternative actions were evaluated based on the following factors:

- Engineering - The engineering evaluation included technical implementability and cost effectiveness.
- Environmental - The environmental evaluation considered potential impacts to the environmental media of air, water, and soil, with consideration of subsequent impacts to vegetation, wildlife, and human health. Particular attention was focused on addressing the significant environmental issues described earlier in Section 1.7.

Actions considered to be acceptable for incorporation into an agency alternative received generally acceptable engineering and environmental ratings. Actions which were eliminated from further evaluation were considered to be unacceptable in terms of engineering feasibility or environmental protection.

2.2.7 Summary of Alternatives

Actions retained for detailed analysis are incorporated into one or more of the Final EIS alternatives described in detail in Sections 2.5 through 2.11. These alternatives are summarized in Tables 2.2-2 and 2.2-3, and identified below.

- Alternative 1: No Action - Mine Expansions Not Approved and Existing Reclamation Plans
- Alternative 2: Mine Expansions Not Approved and Company Proposed Reclamation
- Alternative 3: Mine Expansions Not Approved and Mitigated Reclamation
- Alternative 4: Company Proposed Expansions and Reclamation (CPA)
- Alternative 5: Mitigated Expansion and Reclamation with Leach Pad Located in Upper Alder Gulch rather than on Goslin Flats
- Alternative 6: Mitigated Expansion and Reclamation with Waste Rock Repository Located on Ruby Flats rather than in Carter Gulch
- Alternative 7: Mitigated Expansion and Reclamation with Waste Rock Repository Located on Existing Mine Facilities rather than in Carter Gulch

2.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES

The seven alternatives were evaluated for their potential impact on various environmental, social, and cultural resources. A detailed discussion of these impacts is contained in Chapter 4.

Table 2.3-1 is provided as an impact summary matrix. It contains both quantitative information and/or relative impact rankings for each resource area and for primary issues of concern under the resource areas. Table 2.3-1 also documents where no significant impact is expected for some issues of concern, such as special status species. The rankings shown in Table 2.3-1 are based on professional and technical judgement in view of this particular project, its setting and context, and the effects of this project in both a site-specific and regional sense. More information is available in Chapter 4 regarding methods and criteria used to assess impacts for each resource.

2.4 IMPLEMENTATION AND PREFERRED ALTERNATIVE IDENTIFICATION

There are two decisions that need to be made. One, how to mitigate environmental impacts from existing mine operations. Two, whether ZMI's proposed plans for expanded mining and mineral recovery are adequate to meet state and federal requirements, and if not, to

identify mitigating measures that are needed to meet these requirements. The two decision processes are related in that if expansion is approved it creates some additional options for dealing with impacts from existing mine operations. This does not mean that mine expansion is needed to mitigate existing impacts - just that it could be accomplished differently if done in conjunction with mine expansion.

No sooner than 30-days after this Final EIS is released, a Record of Decision (ROD) will be prepared (see Figure 1-5). The ROD will consider the results of this Final EIS along with the implementation factors and options to *select* a preferred alternative.

Once selected, an alternative may be implemented in various ways. The alternative could be fully implemented, separate decisions could be issued for either of the mines, or implementation of mine expansion could be phased contingent on performance of certain corrective measures. The impact analysis presented in Chapter 4 is based on full implementation of each alternative described in Chapter 2. Implementation of the selected alternative will be decided in the ROD.

During implementation of the decision, the mine operator (ZMI) could propose waivers, exceptions, or modifications be made to the selected alternative. The purpose of this flexibility is to allow consideration of alternative mitigation technologies that may be developed during the life of the project, and to provide for changes that may be warranted due to better knowledge of site conditions gained during operations.

Any changes in operating practices, reclamation design, or mitigating measures would be reviewed by the agencies and accepted if they provide equal or greater resource protection than the original requirement, and did not result in significant impacts previously unidentified by this EIS. Proposed changes which would not achieve the same level of resource protection, or would result in previously undisclosed significant impacts, would require supplemental analysis under NEPA and MEPA prior to approval.

Alternative 7 has been *identified* as the agencies' (BLM and DEQ) preferred alternative. Alternative 7 satisfies the purpose and needs described in Chapter 1.

Of the seven alternatives in this Final EIS, a mine expansion alternative has been identified to meet the need for providing ZMI a means to develop precious metal deposits at the Zortman and Landusky mines and reclaim both mine facilities. Of the various possible waste rock and leach pad facility locations for mine expansion at the Zortman Mine, Alternative 7 is preferred.

Preferred reclamation measures are described under Alternative 7. Modified reclamation covers have been developed to enhance the potential for long-term reclamation success and reduce the potential for surface water to infiltrate into capped facilities. These measures, together with the other mitigations detailed in Alternative 7, would be used to address existing environmental problems, prevent unnecessary or undue degradation, and provide for comparable stability and utility of mined lands with adjacent areas.

TABLE 2.2-1
ALTERNATIVES CONSIDERED FOR THE MINE LIFE EXTENSION PROJECT AT THE ZORTMAN AND LANDUSKY MINES

Category	Alternative	Included/Eliminated for Detailed Analysis	Reason for Inclusion or Elimination
Mining Method	Surface	Included (Alts. 4 5,6,7)	- Viable means of resource extraction for type and grade of ore body.
	Underground	Eliminated	- Technically and economically infeasible for extensive low grade ore body. Reduction in surface impacts minimal due to probable surface subsidence during and after mining.
Mine Reclamation	Low Reclamation Effort	Included (Alt. 1,2)	- May be sufficiently effective in preventing unnecessary or undue degradation or providing comparable utility and stability.
	Moderate Reclamation Effort	Included (Alt. 4)	- May be sufficiently effective in preventing unnecessary or undue degradation or providing comparable utility and stability.
	Extensive Reclamation Effort	Included (Alts. 3,5,6,7)	- Likely to be sufficiently effective in preventing unnecessary or undue degradation or providing comparable utility and stability.
Mine Pit Reclamation	<u>Zortman Pit Complex</u>		
	Complete Pit Backfill	Eliminated	- See Waste Rock Repository Location
	Partial Backfill	Included (Alts. 3,4,5,6,7)	- See Waste Rock Repository Location
	Highwall Reduction	Eliminated	- Area of disturbance nearly doubles if slope reduced to 2H:1V; would not enhance reclamation beyond that provided by partial backfilling and the proposed pit floor and bench reclamation (Alternatives 3, 4, 5, 6, and 7)
	<u>Landusky Pit Complex</u>		
	Complete Pit Backfill	Eliminated	- See Waste Rock Repository Location
	Partial Backfill	Included (Alts. 3,4,5,6,7)	- See Waste Rock Repository Location
	Highwall Reduction	Eliminated	- Area of disturbance nearly doubles if slope reduced to 2H:1V; would not enhance reclamation beyond that provided by partial backfilling and the proposed pit floor and bench reclamation (Alternatives 3, 4, 5, 6, and 7)

TABLE 2.2-1 - ALTERNATIVES CONSIDERED (Continued)

Category	Alternative	Included/Eliminated for Detailed Analysis	Reason for Inclusion or Elimination
Ore Transport	Conveyor	Included (Alts. 4,6,7)	- Efficient long distance transport method with electric power generation capability and low vehicle transport impact potential.
		Eliminated (Alt. 5)	- Inefficient short distance transport method.
		Eliminated (Landusky) (Alts. 4,5,6,7)	- Inefficient short distance transport method.
	Truck Haul	Eliminated (Alts. 4,6,7)	- Inefficient long distance transport method with high vehicle transport impact potential.
		Included (Alt. 5)	- Efficient short distance transport method.
		Included (Landusky) (Alts. 4,5,6,7)	- Efficient short distance transport method.
Beneficiation Technology	Heap Leach	Included (Alts. 4,5,6,7)	- Proven technology for low grade ore with previous applications at this site.
	Milling	Eliminated	- Uneconomical for low grade ore and an impact potential similar to heap leaching.
Conveyor Route	Ruby Gulch	Eliminated	- Passes through community of Zortman.
	Alder Gulch	Included (Alts. 4,6,7)	- Minimizes potential impacts to residential areas.
Process Solution Storage Method	In-Heap	Included	- Moderately efficient storage method with lower loss and environmental exposure for process reagents than for external process ponds.
	External Ponds	Included	- Very efficient storage method with excess capacity for storage of inflow due to storms and solution drain down.

TABLE 2.2-1 - ALTERNATIVES CONSIDERED (Continued)

Category	Alternative	Included/Eliminated for Detailed Analysis	Reason for Inclusion or Elimination
Heap Leach Location	Zortman Ore		
	Goslin Flats	Included (Alts. 4,6,7)	- Sufficient room for pad, ponds, process facilities, and diversions with reasonable ore depths. Ore transport distance made economical by downhill conveyor transport with power generation capabilities.
	Ruby Gulch	Eliminated	- Large upgradient catchment area in steep terrain requiring extensive surface water diversion ditches and heap underdrains. Pad preparation would require extensive earthwork including imported borrow materials. Close proximity to town of Zortman.
	Alder Gulch	Included (Alt. 5)	- Sufficient room for pad, ponds, process facilities and diversions. Short ore transport distance.
	Lodgepole Creek	Eliminated	- Pad preparation would require extensive earthwork including imported borrow materials. Located in drainage with minimal disturbance from existing mining operations; drainage flows directly into the town of Lodgepole on the Fort Belknap Indian Reservation.
	Existing Zortman Pads	Eliminated	- Existing pads are filled to capacity. Off-loading would be uneconomical and would provide insufficient storage capacity for new ore.
	Existing Landusky Pads	Eliminated	- Existing pads are nearly filled to capacity. Long distance ore transport and pad unloading are uneconomical.
	In-Pit at Landusky	Eliminated	- Extensive earthwork would be required to prepare the pit as a pad site. Earthwork and ore transport are uneconomical. Would interfere with proposed pit development.
	In-Pit at Zortman	Eliminated	- Would interfere with proposed pit development.

TABLE 2.2-1 - ALTERNATIVES CONSIDERED
(Continued)

Category	Alternative	Included/Eliminated for Detailed Analysis	Reason for Inclusion or Elimination
Heap Leach Location	<u>Landusky Ore</u>		
(continued)	1987-1991 Pad Expansion	Included (Alts. 4,5,6,7)	- Existing 1987-1991 pad complex has sufficient capacity to accommodate the additional ore included in the proposal.
	1985-1986 Pad Expansion	Eliminated	- Proximity to Montana Gulch stream flows and potential impacts to water quality.
	Other Existing Landusky Pads	Eliminated	- Off-loading and reuse may have limited feasibility at a later date, depending on leaching schedules and economics. This has a reasonably foreseeable use but low probability of immediate practical application.
	In-Pit at Landusky	Eliminated	- Extensive earthwork would be required to prepare the pit as a pad site. Would interfere with proposed pit development. May be reasonably foreseeable at a later date.
	In-Pit at Zortman	Eliminated	- Extensive earthwork would be required to prepare the pit as a pad site. Would interfere with proposed pit development. Earthwork and ore transport are uneconomical.
	Existing Zortman Pads	Eliminated	- Existing pads are filled to capacity. Long distance ore transport and pad unloading are uneconomical.
Heap Leach Reclamation	Neutralize and Reclaim In-Place	Included (All Alts.)	- Proven closure/reclamation method for heap leach operations.
	Low Reclamation Effort	Excluded	- Not sufficiently effective in preventing unnecessary or undue degradation or providing comparable utility and stability.
	Moderate Reclamation Effort	Included (Alts. 1,2,4)	- May be sufficiently effective in preventing unnecessary or undue degradation or providing comparable utility and stability.
	Extensive Reclamation Effort	Included (Alts. 3,5,6,7)	- Likely to be sufficiently effective in preventing unnecessary or undue degradation or providing comparable utility and stability.
	Neutralize and Dispose Off-Site	Eliminated	- Uneconomical for low grade ore. This type of mining operation requires in-place leach pad reclamation to be cost-effective.

TABLE 2.2-1 - ALTERNATIVES CONSIDERED (Continued)

Category	Alternative	Included/Eliminated for Detailed Analysis	Reason for Inclusion or Elimination
Heap Leach Type	Reusable Pad	Eliminated	- Requires uneconomic double handling of ore. Best applied when pad space is limited and ore grades can sustain additional cost.
	Flat Pad	Included (Alts. 4,6,7)	- Proven configuration for open areas (Goslin Flats).
	Valley Leach	Included (Alt. 5)	- Proven configuration for locations in steep drainages with limited upgradient catchment (Alder Gulch).
Processing	Cyanide Leach, Carbon Adsorption or Merril Crowe, Electrowinning, Smelting	Included (Alts. 4,5,6,7)	- Proven technology for low grade ore with previous applications at this project.
	Other Leaching Agents and/or Metal Recovery Systems, Smelting	Eliminated	- Experimental technologies, unproven on ore at this location, and/or less efficient technology for metal recovery based on projected pregnant solution characteristics.
Water Control	Diversions	Included (All Alts.)	- Effective method to minimize surface water flowing on to mine site.
	Capture Systems	Included (All Alts.)	- Minimizes potential for offsite flow of contact water and/or process solution and reduces requirement for fresh water makeup.
	Treatment and Discharge	Included (All Alts.)	- Contact water and/or process solution treated to acceptable quality for discharge.
	Land Application	Included (All Alts.)	- Effective method to dispose of excess contact water and/or process solution.
Waste Rock Transport	Conveyor	Eliminated (Alt. 5)	- Inefficient short distance transport method.
		Included (Alt. 6)	- Efficient long distance transport method with electric power generation capability and low vehicle transport impact potential.
		Eliminated (Landusky)	- Inefficient short distance transport method.
	Truck Haul	Eliminated (Alt. 6)	- Inefficient long distance transport method with high vehicle transport impact potential
		Included (Alts. 4,5,7)	- Efficient short distance transport method.
		Included (Landusky) (Alts. 4,5,6,7)	- Efficient short distance transport method.

TABLE 2.2-1 - ALTERNATIVES CONSIDERED (Continued)

Category	Alternative	Included/Eliminated for Detailed Analysis	Reason for Inclusion or Elimination
Waste Rock Facility Reclamation	Low Reclamation Effort	Eliminated	- Not sufficiently effective in preventing unnecessary or undue degradation or providing comparable utility and stability.
	Moderate Reclamation Effort	Included (Alts. 1,2,4)	- May be sufficiently effective in preventing unnecessary or undue degradation or providing comparable utility and stability.
	Extensive Reclamation Effort	Included (Alts. 3,5,6,7)	- Likely to be sufficiently effective in preventing unnecessary or undue degradation or providing comparable utility and stability.
Waste Rock Repository	<u>Zortman Waste Rock</u>		
Location	Carter Draw of Alder Gulch	Included (Alts. 4,5)	- Short haul. Reduced visual impact. Portion of facility would occupy existing disturbance.
	Upper Ruby Gulch	Eliminated	- Expanded visual impact. Uphill haul uneconomic.
	Lower Ruby Gulch	Eliminated	- Large upgradient catchment area in steep terrain.
	Total Backfill Zortman Pit	Eliminated	- Insufficient material available from extension for complete backfill. While sufficient quantities are available in existing facilities, it is uneconomic to transport the amount necessary for total backfill.
	Total Backfill Landusky Pit	Eliminated	- Uneconomical due to haul distance.
	Partial Backfill Zortman Pit	Included (Alts. 3,4,5,6,7)	- Reduced potential for surface water inflow and ARD generation.
	Partial Backfill Landusky Pit	Eliminated	- Uneconomic haul distance from Zortman pit to Landusky pit.
	Goslin Flats	Eliminated	- Insufficient area next to ore heap leach facility.
	Ruby Flats	Included (Alt. 6)	- Concentrates waste rock and heap leach facilities at one location. Allows transport of both ore and waste rock by conveyor.
	Upper Lodgepole Creek	Eliminated	- Large upgradient catchment area in steep terrain with extensive surface water diversion requirements. Located in drainage with minimal disturbance from existing mining operations which flows directly into the town of Lodgepole on the Fort Belknap Indian Reservation.

TABLE 2.2-1 - ALTERNATIVES CONSIDERED (Concluded)

Category	Alternative	Included/Eliminated for Detailed Analysis	Reason for Inclusion or Elimination
	<u>Landusky Waste Rock</u>		
	Total Backfill Landusky Pit	Eliminated	- Insufficient material available from extension for complete backfill. While sufficient quantities are available in existing facilities, it is uneconomic to transport the amount necessary for total backfill.
	Total Backfill Zortman Pit	Eliminated	- Uneconomic haul distance from Landusky pit to Zortman pit.
	Partial Backfill Landusky Pit	Included (Alts. 3,4,5,6,7)	- Removal, transport of some existing facilities to partially backfill pit economically feasible. Reduced potential for surface water inflow and ARD generation.
	Partial Backfill Zortman Pit	Eliminated	- Uneconomic due to haul distance.

TABLE 2.2-2
SUMMARY OF ALTERNATIVES - ZORTMAN MINE

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion and Reclamation with Leach Pad in Upper Alder Gulch	Alternative 6 - Mitigated Expansion and Reclamation with Waste Rock Facility on Ruby Flats	Alternative 7 - Mitigated Expansion and Reclamation with Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Mine							
Location	97 acres in 6 pits - Ross Pit - South Alabama Pit - North Alabama Pit - OK Pit - Ruby Pit - Mint Pit	97 acres in 6 pits - Ross Pit - South Alabama Pit - North Alabama Pit - OK Pit - Ruby Pit - Mint Pit	97 acres in 6 pits - Ross Pit - South Alabama Pit - North Alabama Pit - OK Pit - Ruby Pit - Mint Pit	Vertical and lateral expansion of mine pit complex; 103 additional acres	Company Proposed Action	Company Proposed Action	Company Proposed Action
Extraction	No additional mining	No additional mining	No additional mining	Open pit, drill, blast, load - 80 million tons ore - 60 million tons waste rock	Company Proposed Action	Company Proposed Action	Company Proposed Action
Ore Transport	Not applicable	Not applicable	Not applicable	Truck to primary crusher and conveyor to leach pad	Truck haul	Company Proposed Action	Company Proposed Action
Waste Rock Transport	Not applicable	Not applicable	Not applicable	Truck haul to Carter Gulch repository	Company Proposed Action	Conveyor to Goslin Flats and truck haul to Ruby Flats	Stage at mine site, backfill, cover facilities
Ore Prep, Handling, and Storage							
Location	None	None	None	Primary crush below truck shop near 84 leach pad; secondary & tertiary crushing at Goslin Flats	All ore crushing near mine site	Company Proposed Action	Company Proposed Action
Crushing	None	None	None	Crush oxide and unoxidized	Company Proposed Action	Company Proposed Action	Company Proposed Action
Stockpile	None	None	None	Separate piles at head of conveyor	At mine site or near Upper Alder leach pad; separate at truck load-out	Company Proposed Action	Company Proposed Action
Conditioning	None	None	None	Blend unoxidized ore with oxide ore	Company Proposed Action	Company Proposed Action	Company Proposed Action

TABLE 2.2-2 - SUMMARY OF ALTERNATIVES - ZORTMAN MINE (Continued)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion and Reclamation with Leach Pad in Upper Alder Gulch	Alternative 6 - Mitigated Expansion and Reclamation with Waste Rock Facility on Ruby Flats	Alternative 7 - Mitigated Expansion and Reclamation with Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Ore Transport							
Location	Not applicable	Not applicable	Not applicable	Alder Gulch route to Goslin Flats, 2.5 acre conveyor corridor	New truck haul route (Antoine Butte) to Upper Alder leach pad	Company Proposed Action	Company Proposed Action
Method	Not applicable	Not applicable	Not applicable	Overland conveyor to Goslin Flats heap leach pad	Haul trucks	Company Proposed Action	Company Proposed Action
Beneficiation (Heap Leaching)							
Location	116 current acres at 7 existing heap leach sites - 79 pad (inactive) - 80/81 pad (inactive) - 82 pad (inactive) - 83 pad (inactive) - 84 pad (inactive) - 85/86 pad (inactive) - 89 pad (active)	116 current acres at 7 existing heap leach sites - 79 pad (inactive) - 80/81 pad (inactive) - 82 pad (inactive) - 83 pad (inactive) - 84 pad (inactive) - 85/86 pad (inactive) - 89 pad (active)	116 current acres at 7 existing heap leach sites - 79 pad (inactive) - 80/81 pad (inactive) - 82 pad (inactive) - 83 pad (inactive) - 84 pad (inactive) - 85/86 pad (inactive) - 89 pad (active)	Goslin Flats heap leach 205 acres	Upper Alder Gulch, heap leach, 180 acres	Company Proposed Action	Company Proposed Action
Method	Valley leach	Valley leach	Valley leach	Modified flat pad	Valley leach	Company Proposed Action	Company Proposed Action
Process Solution Storage							
Location	Existing facilities	Existing facilities	Existing facilities	Goslin Flats	Upper Alder Gulch	Company Proposed Action	Company Proposed Action
Method	In heap and external lined ponds	In heap and external lined ponds	In heap and external lined ponds	In heap and external lined ponds	In heap and external lined ponds	In heap and external lined ponds	In heap and external lined ponds

TABLE 2.2-2 - SUMMARY OF ALTERNATIVES - ZORTMAN MINE (Continued)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion and Reclamation with Leach Pad in Upper Alder Gulch	Alternative 6 - Mitigated Expansion and Reclamation with Waste Rock Facility on Ruby Flats	Alternative 7 - Mitigated Expansion and Reclamation with Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Processing							
Location	Existing process plant, 8.5 acres, 1 site	Existing process plant, 8.5 acres, 1 site	Existing process plant, 8.5 acres, 1 site	Goslin Flats, 23 acres	Existing process plant	Company Proposed Action	Company Proposed Action
Method	Existing Facilities	Existing Facilities	Existing Facilities	Cyanide solution, carbon adsorption, electrowinning, smelting	Company Proposed Action	Company Proposed Action	Company Proposed Action
Mine Waste Disposal							
Waste Rock	25 acres in 3 Dumps - Alder Gulch (3,365,000 tons) - Ruby Gulch (850,000 tons) - OK Dump (1,235,000 tons)	25 Acres in 3 Dumps - Alder Gulch (3,365,000 tons) - Ruby Gulch (850,000 tons) - OK Dump (1,235,000 tons)	Alder Gulch, OK and Ruby Dumps backfilled into pit	New repository in Carter Gulch of Alder Gulch, 162 additional acres; truck haul, bottom-up construction; Alder Dump processed for ore	Company Proposed Action; OK and Ruby Dumps backfilled into pit; Alder Dump processed for ore	New repository on Ruby Flats; conveyor transport and truck haul, bottom-up construction lined impoundment; OK and Ruby Dumps backfilled into pit; Alder Dump processed for ore	New repository constructed over existing mine facilities; OK and Ruby Dumps backfilled into pit; Alder Dump processed for ore
Spent Heap Leach Ore or Tailings	Reclaim in place	Reclaim in place	85/86 leach pad/dike removed for pit backfill; Ruby Gulch tailing removed for use in reclamation; Other facilities reclaimed in place	Reclaim facilities in place; portion of 85/86 pad leached on Goslin Flats leach pad	85/86 leach pad & dike removed for pit backfill; Ruby Gulch tailing used in reclamation or construction; Other facilities reclaimed in place	85/86 leach pad & dike removed for pit backfill; Ruby Gulch tailing used in reclamation or construction; Other facilities reclaimed in place	Ruby Gulch tailing used in reclamation or construction; Other facilities reclaimed in place
Other Solid Waste	Lab wastes to ASARCO smelter, empty cyanide barrels crushed and buried in heap, sludge from water treatment plant to 89 leach pad	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

TABLE 2.2-2 - SUMMARY OF ALTERNATIVES - ZORTMAN MINE (Concluded)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion and Reclamation with Leach Pad in Upper Alder Gulch	Alternative 6 - Mitigated Expansion and Reclamation with Waste Rock Facility on Ruby Flats	Alternative 7 - Mitigated Expansion and Reclamation with Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
<u>Other Facilities</u>							
Access Roads	24 acres existing	24 acres existing	24 acres existing	23 additional acres of access road disturbance	Company Proposed Action	Company Proposed Action	Company Proposed Action
Limestone Quarry	None	None	LS-2 site, northwest of Zortman, in permit boundary	13 acres disturbance, LS-1 site, south of Green Mountain	Company Proposed Action	Company Proposed Action	LS-2 site, northwest of Zortman, in permit boundary
Clay Pit (borrow)	Seaford Clay Pit, 4.2 acres existing, no additional disturbance	Seaford Clay Pit, 4.2 acres existing, 3.0 acres additional disturbance	Seaford Clay Pit, 4.2 acres existing, no additional disturbance	Seaford Clay Pit, 4.2 acres existing, 10 acres additional disturbance	Seaford Clay Pit, 4.2 acres existing, 11.5 acres additional disturbance	Seaford Clay Pit, 4.2 acres existing, 12 acres additional disturbance	Seaford Clay Pit, 4.2 acres existing, additional disturbance for leach pad construction
Top Soil Stockpile	Various locations, 15.5 acres	Various locations, 15.5 acres	Existing stockpiles and Goslin Flats	Goslin Flats, 48 additional acres	Alder Gulch	Company Proposed Action and Ruby Flats	Company Proposed Action
Power Corridor	Existing Facilities	Existing Facilities	Existing Facilities	Buried construction, 9 additional acres	Company Proposed Action	Company Proposed Action	Company Proposed Action
Solution Pipeline	Existing Facilities	Existing Facilities	Existing Facilities	10" pipeline along conveyor route	Existing Facilities	Company Proposed Action	Company Proposed Action
<u>Reclamation</u>							
Mine Pits	Existing permit requirements	Existing permit requirements	Partial backfill pit and Enhanced Reclamation	Partial backfill pit to drain by gravity, revegetate, divert surface water inflows, cover and revegetate benches and pit floor	Enhanced Company Proposed Action Reclamation with additional backfill	Enhanced Company Proposed Action Reclamation with additional backfill	Enhanced Company Proposed Action Reclamation with additional backfill
Waste Rock Dumps and Repositories	Existing permit requirements	Existing permit requirements, cap modifications	Water balance and barrier covers, Alder Gulch and OK dumps used as pit backfill	Concurrent reclamation, capping, revegetation, waste segregation/ encapsulation, Covers A, B or C	Enhanced Company Proposed Action Reclamation, Covers B or Modified C, with OK dump used as pit backfill	Enhanced Company Proposed Action Reclamation, Covers B or Modified C with OK dump used as pit backfill	Enhanced reclamation water balance and water barrier covers
Leach Pads	Existing permit requirements	Existing permit requirements, geochemical testing, Reclamation Cover A	Water balance and barrier covers on heap leach pads, Company Proposed Action with minor modifications	Neutralize in-place with fresh water rinses, perforate liner, capping, revegetation	Enhanced Company Proposed Action Reclamation, Covers B or Modified C on heap leach pads	Enhanced Company Proposed Action Reclamation, covers B or Modified C on heap leach pads	Enhanced reclamation water balance and water barrier covers

TABLE 2.2-3
SUMMARY OF ALTERNATIVES - LANDUSKY MINE

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion (Zortman Mine Leach Pad in Upper Alder Gulch) and Reclamation	Alternative 6 - Mitigated Expansion (Zortman Mine Waste Rock Facility at Ruby Flats) and Reclamation	Alternative 7 - Mitigated Expansion and Reclamation with Zortman Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Mine							
Location	Existing disturbance of 235 Acres in 5 Pits - Queen Rose Pit - August Pit - Little Ben Pit - Gold Bug Pit - Niseka Pit	Same as Alternative 1	Same as Alternative 1	Vertical expansion of existing South Gold Bug pit	Company Proposed Action	Company Proposed Action	Company Proposed Action
Extraction	Open pit, drill, blast, load; permitted disturbance	Same as Alternative 1	Same as Alternative 1	Open pit, drill, blast, load; additional 7.6 million tons ore & 7.0 million tons waste rock	Company Proposed Action	Company Proposed Action	Company Proposed Action
Ore Transport	Truck to 87/91 heap leach pad	Same as Alternative 1	Same as Alternative 1	Truck to expanded 87/91 heap leach pad	Company Proposed Action	Company Proposed Action	Company Proposed Action
Waste Rock Transport	Truck to Gold Bug waste rock repository	Same as Alternative 1	Same as Alternative 1	Truck to expanded Gold Bug waste rock repository	Company Proposed Action	Company Proposed Action	Company Proposed Action
Ore, Prep, Handling, and Storage	All ore run of mine; no stockpiles, crushing, or conditioning	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Ore Transport							
Location	Existing Roads	Existing Roads	Existing Roads	Existing Roads	Existing Roads	Existing Roads	Existing Roads
Method	Truck Haul	Truck Haul	Truck Haul	Truck Haul	Truck Haul	Truck Haul	Truck Haul

TABLE 2.2-3 - SUMMARY OF ALTERNATIVES - LANDUSKY MINE (Continued)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion (Zortman Mine Leach Pad in Upper Alder Gulch) and Reclamation	Alternative 6 - Mitigated Expansion (Zortman Mine Waste Rock Facility at Ruby Flats) and Reclamation	Alternative 7 - Mitigated Expansion and Reclamation with Zortman Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Beneficiation (Heap Leaching)							
Location	280 Current Acres at 8 Existing Heap Leach Sites - 79 pad (inactive) - 80/81/82 pad (inactive) - 83 pad (inactive) - 84 pad (inactive) - 85/86 pad (leaching) - 87 pad (leaching) - 91 pad (loading & leaching) - 87/91 pad (loading & leaching)	Same as Alternative 1	Same as Alternative 1	87/91 pad expansion	Company Proposed Action	Company Proposed Action	Company Proposed Action
Method	Valley Leach	Valley Leach	Valley Leach	Valley Leach	Valley Leach	Valley Leach	Valley Leach
Process Solution Storage							
Location	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities
Method	In Heap and External Lined Pond	In Heap and External Lined Pond	In Heap and External Lined Pond	In Heap and External Lined Pond	In Heap and External Lined Pond	In Heap and External Lined Pond	In Heap and External Lined Pond
Processing							
Location	2 sites - 87 pad - Landusky Plant	2 sites	2 sites	2 sites	2 sites	2 sites	2 sites
Method	Existing facilities, Merrill-Crowe and Carbon Adsorption	Same as Alternative 1	Same as Alternative 1	Same processes as currently used; Merrill-Crowe and Carbon Adsorption	Company Proposed Action	Company Proposed Action	Company Proposed Action

TABLE 2.2-3 - SUMMARY OF ALTERNATIVES - LANDUSKY MINE
(Continued)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion (Zortman Mine Leach Pad in Upper Alder Gulch) and Reclamation	Alternative 6 - Mitigated Expansion (Zortman Mine Waste Rock Facility at Ruby Flats) and Reclamation	Alternative 7 - Mitigated Expansion and Reclamation with Zortman Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Mine Waste Disposal							
Waste Rock	171 acres existing disturbance, 184 acres permitted, in 3 facilities - Montana Gulch (8,000,000 tons) - Mill Gulch (17,000,000 tons) - Gold Bug Repository Plus Heap Leach Pad Embankments (14,000,000 tons)	Same as Alternative 1	Same as Alternative 1	Expand Gold Bug Repository; 7.0 million tons generated during expansion used as pit backfill	Company Proposed Action with additional backfill	Company Proposed Action with additional backfill	Company Proposed Action with additional backfill
Spent Heap Leach Ore	Reclaim in place	Reclaim in place	Reclaim in place, water balance and water barrier covers	Reclaim in place, Company Proposed Action barrier reclamation covers	Reclaim in place enhanced barrier reclamation covers	Reclaim in place enhanced barrier reclamation covers	Reclaim in place water balance and water barrier reclamation covers
Other Solid Waste	Lab wastes to ASARCO smelter, empty cyanide barrels crushed, buried in heap, municipal waste to County landfill	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Other Facilities							
Limestone Quarry	King Creek quarry, 3 acres existing disturbance, no additional disturbance	King Creek quarry, 3 acres existing disturbance, no additional disturbance	Montana Gulch Quarry, 3 acres disturbance	King Creek quarry, 3 acres existing disturbance, 3 acres additional disturbance	King Creek quarry, 3 acres existing disturbance, 3 acres additional disturbance	King Creek quarry, 3 acres existing disturbance, 3 acres additional disturbance	Montana Gulch Quarry, 2 acres disturbance
Clay Pit (borrow)	Williams Pit, 26 acres existing disturbance, no additional disturbance	Williams Pit, 26 acres existing disturbance, 6 acres additional disturbance	No acres additional disturbance	Williams Pit, 26 acres existing disturbance, 7 acres additional disturbance	Williams Pit, 26 acres existing disturbance, 9 acres additional disturbance	Williams Pit, 26 acres existing disturbance, 9 acres additional disturbance	Williams Pit, 26 acres existing disturbance, no acres additional disturbance

TABLE 2.2-3 - SUMMARY OF ALTERNATIVES - LANDUSKY MINE
(Concluded)

Project Components	Alternative 1 - No Action (Permitted Operations and Reclamation)	Alternative 2 - Mine Expansion Not Approved and Company Proposed Reclamation	Alternative 3 - Mine Expansion Not Approved and Mitigated Reclamation	Alternative 4 - Company Proposed Expansion and Reclamation (Company Proposed Action)	Alternative 5 - Mitigated Expansion (Zortman Mine Leach Pad in Upper Alder Gulch) and Reclamation	Alternative 6 - Mitigated Expansion (Zortman Mine Waste Rock Facility at Ruby Flats) and Reclamation	Alternative 7 - Mitigated Expansion and Reclamation with Zortman Waste Rock Repository Located on Existing Mine Facilities (Preferred Alternative)
Other Facilities, Continued							
Top Soil Stockpile	Various Locations	Various Locations	Various Locations	Various Locations	Various Locations	Various Locations	Various Locations
Power Corridor	Existing Facilities	Existing Facilities	Existing Facilities	Buried construction, 9 additional acres, line connecting to Zortman Mine	Company Proposed Action	Company Proposed Action	Company Proposed Action
Solution Pipeline	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities	Existing Facilities
Reclamation							
Mine Pits	Existing permit requirements	Existing permit requirements	Partial backfill pit, water balance and barrier reclamation covers, drainage notch to direct surface water to Montana Gulch	Partial backfill pit to drain by gravity, revegetate, divert surface water inflows, cover and revegetate benches and pit floor; surface water to August drain tunnel	Partial backfill pit, enhanced reclamation covers, direct surface water to King Creek	Partial backfill pit, enhanced reclamation covers, drainage notch to direct surface water to Montana Gulch	Partial backfill pit, water balance and barrier covers, divert surface water and highwall runoff to Montana Gulch
Waste Rock Dumps and Repositories	Existing permit requirements	Existing permit requirements, geochemical testing, Reclamation Cover A	Enhanced reclamation water balance and water barrier covers	Concurrent reclamation, capping, revegetation, waste segregation/encapsulation	Enhanced Company Proposed Action Reclamation, Covers B or Modified C on waste rock facilities	Enhanced Company Proposed Action Reclamation, Covers B or Modified C on waste rock facilities	Enhanced reclamation water balance and water barrier covers
Leach Pads	Existing permit requirements	Existing permit requirements, geochemical testing, Reclamation Cover A	Enhanced reclamation water balance and water barrier covers	Neutralize in-place with fresh water rinses, perforate liner, capping, revegetation	Enhanced Company Proposed Action Reclamation, Covers B or Modified C on heap leach pads	Enhanced Company Proposed Action Reclamation, Covers B or Modified C on heap leach pads	Enhanced reclamation water balance and water barrier covers

TABLE 2.3-1
SUMMARY OF IMPACTS[1]

Resource	ALT. 1		ALT. 2		ALT. 3		ALT. 4		ALT. 5		ALT. 6		ALT. 7	
	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L
WATER RESOURCES														
Surface Water Quality	-High		-High		-Low		-Moderate		-Moderate		-Low		-Low	
Groundwater Quality	-High		-High		-Low		-Moderate		-Moderate		-Low		-Low	
% Infiltration	Flats 23% Slopes 23%		23% 23%		8% 10.5%		0.03% (3:1) 7.8%		0.005% 7.8%		0.005% 7.8%		8% 10.5%	
Volume of Water Requiring Capture and Treatment (gpm average over 20 years)	378-450 gpm		348-419 gpm		211-284 gpm		307-389 gpm		322-423 gpm		244-313 gpm		253-321 gpm	
Overall Cumulative Impact Ranking	-High		-High		-Low to Neutral		-Moderate		-High		-Moderate		-Low	
"Long-Term" Reclamation Success (water quality)	-High		-High		+Moderate		+Low		+Low		+Low		+Moderate	
SOIL RESOURCES														
• Soil Disturbance (cumulative; in acres)	1248		1257		1498		2375		2364		2391		2195	
• Soil Productivity	-High		-High		-Moderate		-Moderate		-Moderate		-Moderate		-Moderate	
• Soil Erosion	-High		-High		-Moderate		-Moderate		-Moderate		-Moderate		-Moderate	
• Total Soil Loss from Major Facilities (tons/acre/year)	3.38		3.38		1.76		1.77		1.63		1.73		1.31	
RECREATION AND LAND USE														
Developed Recreation (campgrounds, picnic areas, Pow Wow grounds)	-Low	-Mod.	-Low	-Mod	-Low	-Low	-Low/ Mod	-Mod	-Low	-Mod	-Mod	-Mod	-Low/ Mod	-Mod
Dispersed Recreation (hiking, sightseeing, ORV, hunting, picnicking)	-Mod	-Mod	-Low/ Mod	-Mod	-Low	-Low	-Mod	-Mod	-Low	-Mod	-High	-Mod	-Mod	-Mod
Land Use	-High	-High	-Mod	-Mod	-Low	-Low	-Mod	-Mod	-Low	-Mod	-High	-Mod	-Mod	-Mod
CULTURAL RESOURCES														
• Overall Impact Level	-Moderate		-Moderate		-Low		-High		-High		-High		-High	
• Relative Ranking (1 = most favorable)	2		2		1		4		3		4		4	

TABLE 2.3-1 - SUMMARY OF IMPACTS[1]
(Continued)

Resource	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT. 5	ALT. 6	ALT. 7
	Z L	Z L	Z L	Z L	Z L	Z L	Z L
WILDLIFE AND AQUATICS							
• Special Status Species	NI	NI	NI	-Low	-Low	-Low	-Low
• Nesting Raptors	NI	NI	NI	NI	NI	NI	NI
• Habitat Loss (in acres)	1248	1257	1498	2212	2282	2431	2064
• Residual Long-term Water Quality Effects	-Moderate	-Moderate	NI	-Moderate	-Moderate	-Moderate	-Low/NI
• Long-term Sedimentation Effects	-Moderate	-Moderate	-Low	-Moderate	-Moderate	-Moderate	-Low
• Long-term Wildlife Mortality	NI	NI	NI	NI	NI	NI	NI
• Noise Effects	NI	NI	NI	NI	NI	NI	NI
• Long-term Reclamation Effects	-High	-High	NI	-Moderate	-Moderate	-Moderate	NI
VEGETATION, WETLANDS AND OTHER WATERS OF THE U.S.							
• Special Status Species Habitat	NI	NI	NI	NI	NI	NI	NI
• Sole Source of Veg. Used by Native Americans	NI	NI	NI	NI	NI	NI	NI
• Forest Vegetation Impacted (cumulative, in acres disturbed)	1029	1029	1034	1387	1550	1245	1285
• Riparian Vegetation Impacted (cumulative, in acres)	16	16	16	26	43	26	25
• Predicted Revegetation Success, as Percent Vegetative Cover	<80%	<80%	>90%	80-89%	80-89%	80-89%	>90%
• Overall Cumulative Vegetation Impacts	-High	-High	-Low	-Moderate	-Moderate	-Moderate	-Low
• Cumulative Wetland Direct Impacts (in acres)	0.03	0.03	0.03	1.09	0.05	1.09	1.09
• Cumulative Wetland Indirect Impacts (in acres)	---	---	1.54	.48	.24	4.07	.48

TABLE 2.3-1 - SUMMARY OF IMPACTS[1]
(Continued)

Resource	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT. 5	ALT. 6	ALT. 7
	Z L	Z L	Z L	Z L	Z L	Z L	Z L
• Cumulative Non-Wetland Waters Direct Impacts (in acres)	4.21	4.21	4.21	7.87	6.29	7.07	7.37
• Cumulative Non-Wetland Waters Indirect Impacts (in acres)	16.0	16.0	16.4	23.3	16.4	24.7	23.3
• Overall Cumulative Wetland Impacts							
Pre-Mitigation	-Low	-Low	-Moderate	-Moderate	-High	-High	-Moderate
Post-Mitigation	-Low	-Low	-Moderate	-Low	-Moderate/Low	-Moderate/Low	-Low
• Overall Cumulative Non-Wetland Waters							
Pre-Mitigation	-High	-High	-High	-High	-High	-High	-High
Post-Mitigation	-High	-High	-Moderate	-Moderate/Low	-Moderate/Low	-Moderate/Low	-Moderate/Low
SOCIOECONOMICS							
Employment							
• Montana employment (cumulative; in job-years)	561	744	909	5,000	4,821	4,524	5,156
• Phillips County employment (cumulative; in job-years)	437	571	698	3,480	3,356	3,173	3,608
• Blaine County employment (cumulative; in job-years)	20	26	32	144	139	133	133
Earnings							
• Montana earnings (cumulative; in millions of 1994 dollars)	$14.8	$19.5	$23.8	$126.4	$121.8	$114.8	$130.6
• Phillips County earnings (cumulative; in millions of 1994 dollars)	$12.3	$16.0	$19.6	$95.6	$92.2	$87.4	$99.3
• Blaine County earnings (cumulative; in millions of 1994 dollars)	$0.4	$0.5	$.06	$2.6	$2.5	$2.4	$2.7

TABLE 2.3-1 - SUMMARY OF IMPACTS[1] (Continued)

Resource	ALT. 1		ALT. 2		ALT. 3		ALT. 4		ALT. 5		ALT. 6		ALT. 7	
	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L
Tax Revenues														
• Montana direct tax revenues (cumulative; in millions of 1994 dollars)	$0.44		$0.44		$0.44		$4.46		$4.30		$3.60		$4.29	
• Phillips County tax revenues (cumulative; in millions of 1994 dollars)	$0.25		$0.25		$0.25		$2.63		$2.57		$2.44		$2.61	
• Malta School Districts direct tax revenues (cumulative; millions of 1994 dollars)	$0.12		$0.12		$0.12		$1.25		$1.22		$1.15		$1.24	
• Dodson High School District direct tax revenues (cumulative; in millions of 1994 dollars)	$0.11		$0.11		$0.11		$1.12		$1.10		$1.03		$1.11	
• Landusky School District direct tax revenues (cumulative; in millions of 1994 dollars)	$0.07		$0.07		$0.07		$0.73		$0.72		$0.68		$0.73	
• City of Malta direct tax revenues (cumulative; in 1994 dollars)	Negligible		Negligible		Negligible		<$10,000		<$10,000		<$10,000		$10,000	
• County Hard Rock Trust Reserve district tax revenues (cumulative; in millions of 1994 dollars)	$0.06		$0.06		$0.06		$0.59		$0.57		$0.48		$0.57	
TRANSPORTATION														
• Traffic Capacity	-Low		-Low		-Low		-Low		-Low		-Low		-Low	
• Accidents	-Low		-Low		-Low		-Low		-Low		-Low		-Low	
• Transport of Hazardous Materials	-Low		-Low		-Low		-Low		-Low		-Low		-Low	
• Public Access to Parts of the LRM (duration of impact - until _year_)	-High (until 2001)		-High (until 2001)		-High (until 2002)		-High (until 2008)		-High (until 2008)		-High (until 2007)		-High (until 2008)	
• Safety in Local Communities	-Low	-Low	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	-Mod	NI
(# convoyed truck trips thru town per day; duration in peak year)	0	0	300 trip 12 days	300 trip 27 days	300 trip 14 days	300 trip 35 days	300 trip 17 days	300 trip 27 days	300 trip 25 days	300 trip 27 days	300 trip 14 days	300 trip 27 days	240 trip 42 days	0

TABLE 2.3-1 - SUMMARY OF IMPACTS[1]
(Continued)

Resource	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT. 5	ALT. 6	ALT. 7
	Z L	Z L	Z L	Z L	Z L	Z L	Z L
VISUAL RESOURCES	-High	-High	-High	-High	-High	-High	-High
NOISE[2] (in dBA; all impacts negative)							
• Cumulative Mine Noise Impacts, Town of Zortman	59 dBA High	59 dBA High	62 dBA High	66 dBA High	60 dBA High	67 dBA High	64 dBA High
• Cumulative Mine Noise Impacts, Town of Landusky	62 dBA High	62 dBA High	62 dBA High	63 dBA High	62 dBA High	63 dBA High	63 dBA High
• Cumulative Mine Noise Impacts, Pow Wow Grounds	58 dBA High	58 dBA High	58 dBA High	59 dBA High	59 dBA High	59 dBA High	59 dBA High
• Cumulative Mine Noise Impacts, Azure Cave	55 dBA Moderate	55 dBA Moderate	59 dBA High	66 dBA High	57 dBA Moderate	66 dBA High	60 dBA High
AIR[3] (in $\mu g/m^3$)							
• 24-hour and Annual PM_{10} Mining and Reclamation Impacts, Estimated at Town of Zortman	32 $\mu g/m^3$ NI 8 $\mu g/m^3$ NI	57 $\mu g/m^3$ Low 14 $\mu g/m^3$ NI	100 $\mu g/m^3$ Mod 4 $\mu g/m^3$ NI	76 $\mu g/m^3$ Low 4 $\mu g/m^3$ NI	158 $\mu g/m^3$ High 6 $\mu g/m^3$ NI	59 $\mu g/m^3$ Low 5 $\mu g/m^3$ NI	118 $\mu g/m^3$ Mod 5 $\mu g/m^3$ NI
• Cumulative 24-Hour PM_{10} Impacts, Estimated at Town of Zortman	62 $\mu g/m^3$ Low	87 $\mu g/m^3$ Low	130 $\mu g/m^3$ Mod	295 $\mu g/m^3$ High	188 $\mu g/m^3$ High	278 $\mu g/m^3$ High	148 $\mu g/m^3$ Mod
• 24-hour and Annual PM_{10} Mining and Reclamation Impacts, Estimated at Landusky Mine	85 $\mu g/m^3$ Mod 14 $\mu g/m^3$ NI	85 $\mu g/m^3$ Mod 25 $\mu g/m^3$ Low	85 $\mu g/m^3$ Mod 31 $\mu g/m^3$ Low	85 $\mu g/m^3$ Mod 31 $\mu g/m^3$ Low	85 $\mu g/m^3$ Mod 32 $\mu g/m^3$ Low	85 $\mu g/m^3$ Mod 32 $\mu g/m^3$ Low	85 $\mu g/m^3$ Mod 32 $\mu g/m^3$ Low
• Cumulative 24-Hour PM_{10} Impacts, Estimated at Town of Landusky	129 $\mu g/m^3$ Mod	140 $\mu g/m^3$ Mod	146 $\mu g/m^3$ Mod	146 $\mu g/m^3$ Mod	147 $\mu g/m^3$ Mod	147 $\mu g/m^3$ Mod	147 $\mu g/m^3$ Mod
HAZARDOUS MATERIALS	-Low	-Low	-Low	-Moderate	-Moderate	-Moderate	-Moderate

TABLE 2.3-1 - SUMMARY OF IMPACTS[1]
(Concluded)

Resource	ALT. 1		ALT. 2		ALT. 3		ALT. 4		ALT. 5		ALT. 6		ALT. 7	
	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L	Z	L
GEOLOGY														
• Disturbance for Construction and Reclamation Materials (in acres)	0	0	3	6	65	0	23	10	25.5	12	25	12	17	3
• Cumulative Disturbance for Construction and Reclamation (in acres)	4.2	29	7.2	35	69.2	29	27.2	39	29.7	41	29.2	41	21.2	32
• Anticipated Gold Production (in Troy ounces)	0 oz.		0 oz.		0 oz.		960,000 oz.		960,000 oz.		804,000 oz.		960,000 oz.	
• Anticipated cumulative Gold Production plus Reasonably Foreseeable (in Troy ounces)	1.4 million oz.		1.4 million oz.		1.4 million oz.		2.64 million oz.		2.6 million oz.		2.48 million oz.		2.64 million oz	
ACECs (Areas of Critical Environmental Concern)														
• Azure Cave (and associated bat habitat)	NI		NI		NI		Low		NI		Low		Low	
• Prairie Dog Towns	NI		NI		NI		NI		NI		NI		NI	
• Little Rocky Mountains (proposed)	NI		NI		NI		-Moderate		-Low		-Moderate		-Moderate	
• Saddle Butte (proposed)	NI		NI		NI		NI		NI		NI		NI	
• Old Scraggy Peak (proposed)	NI		NI		NI		-Moderate		-Moderate		-Moderate		-Moderate	

Notes:
[1] Where applicable, impacts are differentiated by Zortman Mine (Z) and Landusky Mine (L)
[2] Significance threshold is 55 dBA, the estimated level above which noise would interfere with outdoor activity.
[3] Significance thresholds are the 24-Hour, PM_{10} standard of 50 $\mu g/m^3$; and the Annual PM_{10} standard of 150 $\mu g/m^3$.

Key:
- = Negative impact
+ = Positive impact

High = High level of impact (significant)
Mod/Moderate = Moderate level of impact
Low = Low level of impact
NI = Negligible impact

2.5 ALTERNATIVE 1 (NO ACTION): MINE EXPANSIONS NOT APPROVED AND EXISTING RECLAMATION PLANS

Council on Environmental Quality Regulations at 40 CFR §1502.14(d) require that environmental impact statements include an evaluation of a No Action Alternative. This alternative serves as a baseline description of the current conditions at the Zortman and Landusky mines, as well as future conditions that would result from the agencies not approving additional mining and not modifying the existing reclamation plans. Figure 2.5-1 and Exhibits 1 and 2 show the existing facilities at both the Zortman and Landusky mines.

This alternative would not void existing, approved mining and reclamation operations already permitted, or alter corrective measures already in place or those required in the future by other agencies for water quality improvement. The No Action Alternative is described in the following sections as the existing conditions and permitted operations for both the Zortman and Landusky mines. Chapter 4.0 of this Final EIS presents an evaluation of the environmental impacts that have already occurred from the two mines, and those impacts projected to occur in the future given current permit requirements for operation and reclamation at the two mines.

This alternative is presented in four sections:

- Section 2.5.1 describes the existing operations at the Zortman and Landusky mines.
- Section 2.5.2 describes the existing reclamation procedures at the Zortman and Landusky mines.
- Section 2.5.3 describes the monitoring programs in place at the two mines, as well as long-term research programs which have been initiated to evaluate environmental control methods and materials.
- Section 2.5.4 presents an evaluation of future activities which have a reasonably foreseeable opportunity of occurrence under this alternative.

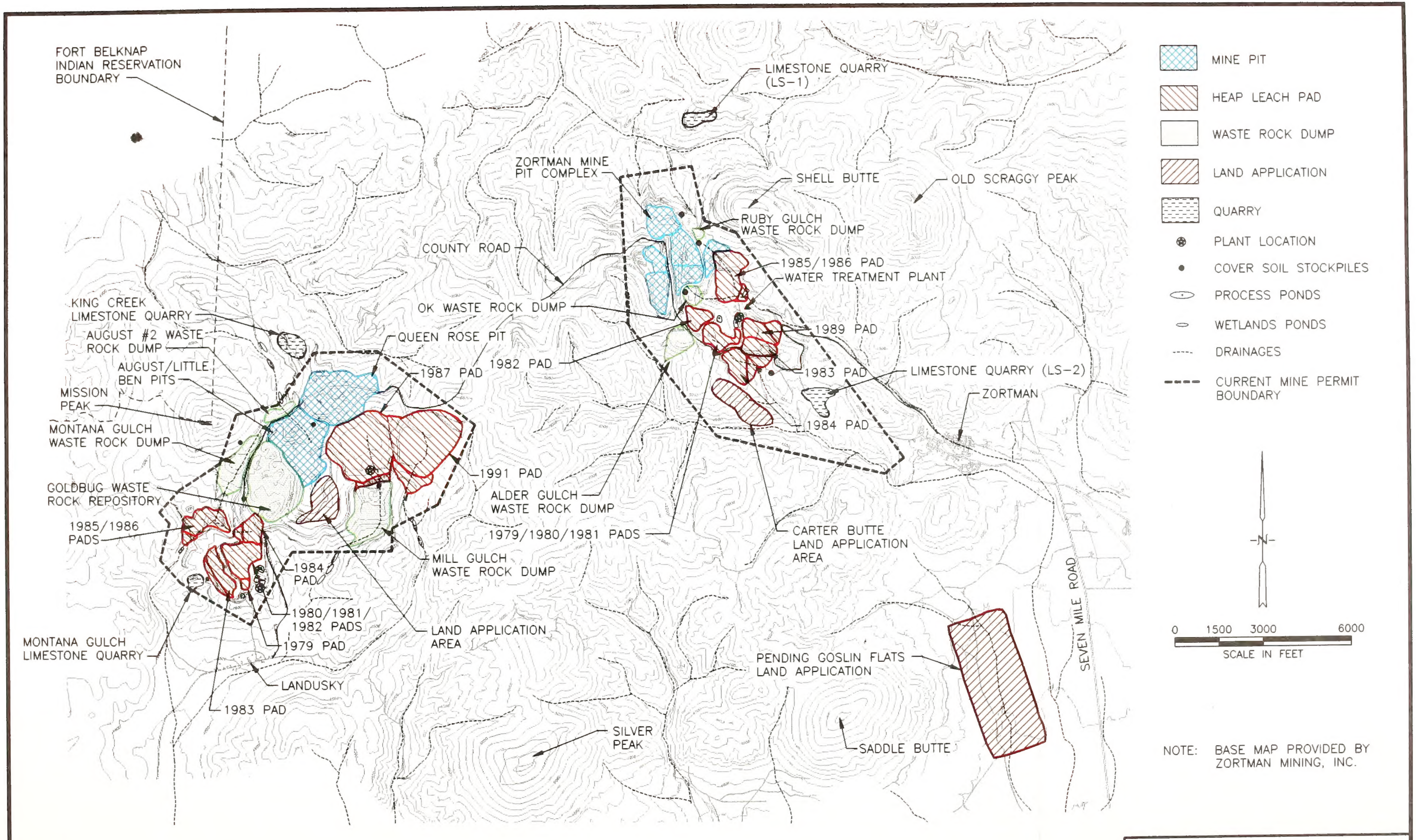
2.5.1 Existing Mine Operations

The location, currently permitted area, and major facilities of the Zortman Mine are shown on Figure 2.5-1, and Exhibit 1 located in the map pocket of this document. The Zortman Mine is situated in portions of Sections 7, 17, and 18 of Township 25N, Range 25E, approximately one mile northwest of the town of Zortman in the Little Rocky Mountains. The mine has been in operation since 1979, using open-pit mining and heap-leach mineral processing to extract gold and silver from ore.

Production has varied during the approximately 15 years of mine operation. A combined total of about 26 million tons of ore and waste rock have been mined during that period. No ore has been mined at the Zortman Mine since 1990 although some ore is still being leached to recover the precious metals.

The location, currently permitted area, and major facilities of the Landusky Mine are shown on Figure 2.5-1, and Exhibit 2 located in the map pocket of this document. The Landusky Mine is situated in portions of Sections 14, 15, 22, and 23 of Township 25N, Range 24E, approximately one mile north of the community of Landusky in the Little Rocky Mountains. The mine has been in operation since 1979. The mining operation is located on 1,287 acres of land, of which 382 acres are patented mining claims. A total of 814 acres of these lands are permitted for disturbance.

In contrast to the Zortman Mine, ore is being mined from the Landusky Mine at this time. There is no remaining, permitted capacity for additional ore to be loaded at the Landusky leach pads. Production was approximately 12 million tons of ore and 6 million tons of waste rock per year. The number of workers employed at the mines has varied over the years, depending on the production rates and reclamation activities. ZMI employed N.A. Degerstrom, a contract mining firm, from 1979 until 1991. Since that time ZMI has been using its own work force for mining operations at both the Zortman and Landusky mines. When both



ALTERNATIVE 1: EXISTING MINE FACILITIES ARE SHOWN AS WELL AS THE PENDING GOSLIN FLATS LAND APPLICATION AREA

ALTERNATIVE 1
ZORTMAN-LANDUSKY
EXISTING AND PENDING
FACILITY LOCATIONS

FIG. 2.5-1

ZLF-ALT1

mines are operating, the combined work force is about 200 persons, with another 20 or so workers hired for reclamation activities and other seasonal work during the spring and summer months. The combined work force has included as many as 250 workers at times, depending on the amount of reclamation, exploration, and mining activity underway.

2.5.1.1 Mine Pit Operation

The Zortman Mine has developed into a single pit complex by connecting six adjacent open pits. The six smaller pits forming the current pit complex are the South Alabama, North Alabama, OK, Ruby-Ross, Independant, and Mint pits. Table 2.5-1 shows the estimated area of mine pit disturbance under the existing permit conditions, as well as the actual existing disturbance. Mining is not presently taking place in any of the Zortman Mine pits.

The Landusky Mine has developed a number of open pits, including the Little Ben, Suprise, August, Queen Rose, Gold Bug, and South Gold Bug pits. Many of the pits have been enveloped by larger or expanded operations over the years, and all of the pits are contiguous. As shown on Table 2.5-2, ZMI has reached the extent of permitted mine pit disturbance, as approximately 235 acres have been disturbed by the open pits. Ore has most recently been mined from the Queen Rose, Little Ben, and South Gold Bug pits.

Mining Methods

Although ore is not currently being mined from the Zortman pit, a description of the process used to remove rock from the open pit complex follows. Ore was mined via drill, blast, and dump methods using shovels, loaders, and haul trucks. Rotary drill rigs bore blasting holes on ore benches using a grid of approximately 13' by 13' centers. A mixture of ammonium nitrate and fuel oil (ANFO) has been used as the main blasting agent.

Once ore has been extracted from the pits by blasting, loading, and hauling it is taken directly to a heap leach pad. Ore which is deposited directly on a heap leach pad for mineral extraction is known as "run-of-mine" ore. This means the ore mined to date at both mines has been immediately amenable to mineral extraction by heap leaching, without crushing or other pre-leach processing. Typically, this is ore which has been oxidized. Unoxidized ore would require crushing to provide more surface area for the cyanide used in heap leaching to dissolve the gold and silver minerals into solution. Large volumes of unoxidized ore (also called "sulfide ore") have not been mined at Zortman to date, although proposed future mining would include a significant amount of this type of material (see Section 2.8.1.1).

Methods used to remove ore from the Landusky Mine have been the same as those described for the Zortman Mine. Approximately 117 million tons of ore have been leached to remove gold and silver at the Landusky Mine site since ZMI began operations in 1979. More information concerning the geology of the area, the rock types encountered and mined, and common mineral associations may be found in Section 3.1.

Rock Characterization

Whether ore at the mines has been oxidized or not has much practical importance beyond its crushing requirements, for two primary reasons:

1. Oxidation of the ore generally has occurred nearest the surface, and along fractures which have transported surface water deeper into the ore zones. This makes it relatively easy to extract gold and silver from oxidized host rock using heap leaching processes. Unoxidized ore tends to have gold and silver bound up in the geochemical matrix of the rock, thereby making it more difficult to release the minerals from the ore using heap leaching processes.

2. Oxidized ore is generally less likely to cause problems associated with ARD than unoxidized ore. ARD can be produced when sulfide minerals, such as those which are typically found with gold and silver in the Zortman and Landusky deposits, produce sulfuric acid upon exposure to water and oxygen. This action lowers the pH of the water which, if the pH is low enough, can dissolve heavy metals in the surrounding rock leading to contamination of groundwater and/or surface water.

Approximately 36 percent of the material removed during operations at the Zortman Mine has been waste rock; in other words, the rock has insufficient content of gold or silver to be worth processing. Waste rock generated during mining has to be removed from the area and dumped or placed in a special facility. Problems have occurred at both the Zortman and Landusky mines because some waste rock has caused the formation of ARD. However, in the past there has been no program for rock characterization at the Zortman Mine to distinguish and selectively handle wastes which have the potential to generate acid drainage. Waste rock was used in construction of leach

TABLE 2.5-1
SUMMARY OF MINE PIT CONDITIONS
ZORTMAN MINE

Pits	Permitted Disturbance (Area in Acres)[1]	Existing Disturbance (Area in Acres)[1]	Operational Status
Zortman Pit Complex[2]			
OK, Ross & Ruby	66.6	58.7	Inactive
North Alabama & South Alabama	23.3	33.4	Inactive
Mint	6.9	4.3	Inactive
TOTAL	96.8	96.4	

Source:

1 ZMI Revised Application for Amendment to Permit 00096, January, 1994.
2 All pits at Zortman have been connected into one open pit complex.

TABLE 2.5-2
SUMMARY OF MINE PIT CONDITIONS
LANDUSKY MINE

Pits	Permitted Disturbance (Area in Acres)[1]	Existing Disturbance (Area in Acres)[1]	Operational Status
Landusky Pits			
Queen Rose and August[2]	109.0	148.5	Active
Gold Bug	86.0	86.4	Backfilling
South Gold Bug	20.0	0.0	Developing
TOTAL	215.0	234.9[3]	

Source:

1 Revisions to Landusky Operating Plan, July, 1995 (ZMI 1995a)
2 Includes Little Ben and Suprise pits
3 Includes haul roads

pads and leach pad dikes, or placed in dumps without regard for acid generating potential.

Approximately 50 million tons or one-third of the total material removed during operations at the Landusky Mine has been waste rock. Waste rock generated during mining has to be removed from the pit and dumped or placed in a waste rock disposal facility. As with the Zortman Mine, problems have occurred because the chemistry of some waste rock has been conducive to development of ARD. Until 1993, the permit requirements allowed waste rock to be dumped into waste rock facilities without regard for their potential to cause acid drainage. In 1993, ZMI implemented a waste rock characterization and handling program at the Landusky Mine to segregate waste materials with a significant acid generation potential. The program is as follows:

Mine wastes are characterized by their total sulfur content, with analyses being conducted using a Leco SC432 analyzer to measure sulfur content of every third blast hole drilled during mining operations. To ensure the validity of classification schemes, 300 - 500 check samples are analyzed for total sulfur, and net neutralization potential per year. In addition, laboratory-scale humidity cells tests and field-scale tests are ongoing.

The principal objective of characterization work is the identification of waste with acid generating potential, so that it can be handled appropriately. A secondary consideration is identification of waste with substantial neutralization potential which can be used for unrestricted construction. Static data from 815 samples are available. Based on these data, correlated with sulfur content of the waste rock analyzed, ZMI has assigned color-coded handling classifications which are described below:

- **Blue Waste (< 0.2 percent sulfur; Non-Acid Forming)**

  A substantial portion of the blue waste material is composed of felsic porphyries of several different oxidized or unoxidized lithologies and calcareous shales of the Emerson Formation.

- **Yellow Waste (0.2 - 0.5 percent sulfur; Uncertain)**

  The bulk of the yellow waste is composed of unoxidized or partially oxidized porphyries, and similarly mineralized and altered amphibolite facies schists and gneisses.

- **Green Waste (> 0.5 percent sulfur; Acid-Forming)**

  The bulk of the green waste materials are partially oxidized felsic porphyries and/or amphibolite-facies felsic gneisses.

The sulfur values of every third blast hole sample are plotted with the gold assays when ore and waste blocks are discriminated. Any ore materials, regardless of sulfur content, which are disturbed during oxide ore mining operations, are taken to the leach pads with the oxide ores. The remaining materials are assigned to blocks which are classified on the basis of the most restrictive waste category included in any given block. This waste rock handling system was given approval by the agencies (DSL/BLM 1994a) for selecting non-acid generating waste rock to be used for interim reclamation of the Mill Gulch and Gold Bug waste rock repositories, and 91 pad dike. This decision was contingent upon the "Blue Waste" also having a net neutralization potential greater than 20 and a NP/AP ratio greater than 3.

Waste Rock Handling

After waste rock is geochemically characterized, it is scheduled for placement into a waste rock disposal facility (see Section 2.5.1.4). ZMI has developed the following waste classification rules for determining appropriate disposition of the waste rock at the Landusky Mine:

- Any block which contains only blue waste blast holes is scheduled as blue waste.
- Any block which contains a mixture of blue waste blast holes and yellow waste blast holes is scheduled as yellow waste.
- Any block which contains any green waste blast holes is scheduled as green waste.
- Any uncharacterized waste of uncertain character is scheduled as green waste.

2.5.1.2 Crushing Operation

The ore processing at the mines has been for run-of-mine ore, such that crushing has not been necessary to prepare the ore for heap leaching. The only crushing operations that have been conducted were to prepare a bed of smaller sized ore to place over the bottom of heap leach pads. The smaller ore fragments serve as a layer of protection, to reduce the potential for tears or

punctures in the heap leach pad liner. Some crushed waste rock has also been used for road bed surfacing.

2.5.1.3 Ore Leaching Operation

Since 1979, seven separate heap leach pads have been used at the Zortman Mine. Leach pads are named by the year of construction. They are the 79, 80/81, 82, 83, 84, 85/86, and 89 pads. The locations of these leach pads are shown on Figure 2.5-1.

The 79, 80/81, and 82 leach pads are located near ridge tops and do not have dike structures. These pads are free draining. All other pads are lined valley-fill structures with in-heap storage of process solution behind a cross-valley dike. Each of these heap leach facilities generally include the following components: (1) the containment dike or buttress; (2) the lined pad; (3) the spent ore on the pad; and (4) the lined contingency ponds.

Since 1979, seven separate or combined heap leach pads have been used at the Landusky Mine. They include the 79, 80/81/82, 83, 84, 85/86, 87, and 91 pads. The 87 and 91 pads have recently been combined to form the 87/91 pad. The locations of these pads are shown on Figure 2.5-1.

The next four subsections provide a description of the methods used in constructing and developing these pads, and the current status of the facilities, The fifth, Processing Plant Operation, describes the process used to remove the metals from the leach solution.

Leach Pad Construction

The basic construction method used in development of heap leach pads is as follows. The area to be covered by the heap leach pad is cleared of vegetation, loose rock, and other debris such as historic mine tailing. Cover soil is removed and placed in storage piles. An underdrain system is prepared to transport natural drainage water and runoff which is present beneath the pad. The underdrain is constructed of uniformly sized rock that should not decompose or disintegrate when repeatedly wetted. The underdrain and water storage capacity within the pad are designed to be sufficient to handle large storm events from the entire drainage basin.

At the Zortman Mine, the heap leach pad and retaining dike are constructed on top of the prepared surface and underdrain. Waste rock is used to fill irregularities and serve as a base for the pad liner. The dike provides stability and helps to contain leaching solutions. A liner is installed at the base of the leach pad, typically consisting of a compacted clay layer upon which is placed a synthetic membrane of polyvinyl chloride. A layer of crushed rock, tailing, or other fine grained material is placed on the plastic liner to reduce the potential for puncture. The pad is then ready for ore to be loaded and leached. The Zortman 79, 80/81, and 82 pads are lined with compacted clay only. The remaining pads are lined with compacted clay and a synthetic membrane.

Table 2.5-3 provides a summary of the ore capacity for each leach pad, and disturbances associated with the leach pads. Approximately 145 acres have been disturbed by leach pad development. About 20 million tons of ore have been loaded on the leach pads and six of the seven pads have been loaded to the permitted capacity. Ore is still being leached at the 89 pad. A summary of leach pad reclamation is presented in Section 2.5.2.4.

The Landusky 79 and 80/81/82 pads are free draining, while the remaining pads are valley-fill structures. The 79, and 80/81/82 pads are lined only with compacted clay. The remaining Landusky leach pads are lined with both compacted clay and a synthetic membrane of PVC. Table 2.5-4 provides a summary of the ore capacity for each pad, and disturbances associated with the leach pads. Approximately 280 acres have been disturbed by leach pad development. About 107 million tons of ore have been loaded on the leach pads, and all but the 91 and 87/91 have been loaded to their permitted capacity. Ore is still being leached at the 85/86, 87, and 91 pads.

In March, 1994, the agencies issued a Decision Record requiring that ZMI not construct the previously approved 85/86 leach pad extension because of potential impacts to surface and groundwater in Montana Gulch. Instead, the ore remaining to be loaded on this pad was to be placed on an extension of the 87 and 91 pads, effectively connecting the two pads. This new area is designated the 87/91 heap leach pad. A summary of the reclamation status for each facility is presented in Section 2.5.2.4.

Leach Pad Operation

The leach pads at Zortman and Landusky have generally used the same procedures to remove minerals from ore. Run-of-mine ore is stacked on the pad in 25-foot lifts. Diluted cyanide solution is sprayed or sprinkled on the heaps using a system of hoses and solution distributors similar to an irrigation device. As the cyanide solution trickles down through the heap it leaches gold and silver from the ore. The liquid at the bottom of the heap is collected by wells and either redistributed to the top for additional irrigation or, if it is carrying sufficient

TABLE 2.5-3
SUMMARY OF CURRENT HEAP LEACH PAD CONDITIONS
ZORTMAN MINE

Facility	Permitted Disturbance (Area in Acres)	Total Permitted Ore (Tons)[1]	Current Mass Load (% of Total)	Maximum Solution Capacity (10^6 Gal)[1]	Solution In Storage (10^6 Gal)[1,2]	Remaining Solution Capacity (10^6 Gal)[1,2]	Operational Status and History
79	4.7	218,000	100	0	0	0	Reclaiming
80/81	14.0	1,698,000	100	0	0	0	Reclaiming
82	16.1	1,889,000	100	0	0	0	Inactive: Designed to drain into pregnant pond
83	10.9	2,008,000	100	8.94	6.46	2.48	Rinsing and reclaiming
84	17.7	2,389,000	100	10.37	4.69	5.68	Rinsing and reclaiming
85/86	33.7	7,988,000	100	11.96	5.83	6.13	Rinsing
89	18.6	4,000,000	92	17.44	11.91	5.53	Rinsing and reclaiming
TOTAL	115.7	20,190,000		48.71	28.89	19.82	

Source:

1 ZMI Revised Application for Amendment to Permit 00096, January, 1995.
2 As of September 1, 1994.

TABLE 2.5-4
SUMMARY OF CURRENT HEAP LEACH PAD CONDITIONS
LANDUSKY MINE

Facility	Permitted Disturbance (Area in Acres)	Permitted Ore (Total)[1]	Current Mass Load (% of Total)	Maximum Solution Capacity (10^6 Gal)[1]	Solution In Storage (10^6 Gal)[2]	Remaining Solution Capacity (10^6 Gal)[2]	Operational Status
79	7.0	458,000	100	0	0	0	Reclaiming
80/81/82	25.5	3,694,000	100	0	0	0	Rinsing
83	22.0	2,021,000	100	10.56	3.13	7.44	Rinsing
84	13.5	3,301,000	100	9.54	1.44	8.10	Rinsing
85/86	26.1	5,300,000	100	23.21	13.67	9.54	Leaching: Fully loaded, but at 30 percent original capacity. Loading deferred to 87 & 91 pads to reduce ARD contamination potential
87	82.0	40,000,000	100	116.84	59.49	57.35	Leaching
91	78.5	50,000,000	100	153.61	109.61	44.01	Loading & Leaching
87/91	25.0	11,900,000	84	0	0	0	Loading & Leaching: No additional solution capacity
TOTAL	279.60	116,674,000	98%	313.76	187.34	126.44	

Source:

1 Draft Revisions to Landusky Operating Plan, April 1995 (ZMI 1995a)
2 As of January 12, 1996 (Ryan 1996)

quantities of metal, sent to the process plant. The solution sent to the process plant is called "pregnant" solution.

As this process continues, the amount of gold released from the ore to the leach solution is reduced with successive flushes. Eventually, it becomes inefficient to continue leaching that lift and a new load of ore is placed on the heap leach pad.

Process Ponds

At Zortman Mine, the pregnant solution carrying metals is directed to solution holding ponds prior to further processing. Process pond capacity varies depending upon water balance within the heaps and ponds. Table 2.5-5 provides the solution capacities and current solution containment within the two process ponds at Zortman. The pregnant pond has a capacity of 4.78 million gallons. The barren pond, so called because it contains a solution which has had the metals removed, has a similar capacity. The 82 contingency pond can also be used for solution storage. All of these ponds are operationally active, since the leach pads are still being used to collect metals in cyanide solution. The pregnant and barren ponds for the Zortman Mine are located adjacent to the 80/81 and 89 leach pads, as shown on Figure 2.5-1.

Table 2.5-6 provides the solution capacities and current solution containment within the three process ponds at the Landusky Mine. The pregnant pond carrying gold and silver has a capacity of about 4.96 million gallons, with approximately 30 percent capacity available for more solution. The Landusky Mine has two barren process ponds, containing solution from which the metals have been removed. These three ponds are all active since ore leaching is still occurring at some of the heap leach pads. Locations of the pregnant and barren ponds are shown on Figure 2.5-1.

Leak Detection System

The capability to monitor the existing leach pads depends on the method of construction. Valley fill leach pads have underdrains which are used to monitor for any leakage through the liner. Free draining pads have no specific leak detection system but use adjacent monitoring wells to determine if groundwater below the leach pads has been degraded by solution leaks (an example of leach pad construction is displayed on Figure 8 of Appendix 1 to the Zortman Mine Permit Application). The monitoring well network at the Zortman Mine is shown on Exhibit 1. The monitoring well and surface water monitoring network at the Landusky Mine is shown on Exhibit 2. These monitoring programs are discussed in Section 2.5.3.

Processing Plant Operation

The processing plant to recover the gold and silver from the cyanide solution at the Zortman Mine is located adjacent to the Zortman 80/81 and 89 leach pads (see Figure 2.5-1). The Zortman Mine has used the "Merrill-Crowe" process to remove precious metals from pregnant solution. Pregnant solution is passed through a tower to de-aerate the liquid, then to a set of filters which remove suspended solids. Zinc powder is added, after which the solution passes through another set of filters to precipitate gold and silver. Makeup water, additional cyanide, and lime for pH control are added to the solution in a mixing tank, after which the solution is sent to the barren pond to begin a new cycle of sprinkling, leaching, collection, and processing. The zinc precipitate is removed from the filters periodically with a caustic (high-pH) solution. The precipitate is then mixed with a flux and smelted in a refinery, located adjacent to the Merrill-Crowe Plant, to produce dore, a mixture of mostly silver and gold. The dore is stored on-site until it is shipped by truck to a commercial refinery for further processing.

The processing plants used to recover the gold and silver from the cyanide solution at the Landusky Mine are located just north of the 87 leach pad dike (carbon adsorption) and adjacent to the 79 pad (Merrill-Crowe) as shown on Figure 2.5-1. Pregnant solution is pumped from the leach pads via vertical turbine pumps to the Merrill-Crowe or to the carbon adsorption facilities, with a capability to process approximately 5,000 gallons per minute combined. The Merrill-Crowe plant operates as described above for the Zortman Mine. In the carbon adsorption plant, columns filled with activated carbon collect metals from solution through an adsorption process. Pregnant solution enters a column from the bottom and proceeds upward, contacting carbon along the way which has adsorbed the gold and silver. The solution then overflows into a collection system where it gravity-feeds into the next column. The solution proceeds in this manner through all of the carbon columns, exiting the last one as barren solution void of gold or silver.

2.5.1.4 Waste Rock Facilities

The waste rock facilities at the Zortman and Landusky mines are classified as either a "Dump" or a "Repository." Waste rock dumps are those which have been developed by end-dumping waste rock from an elevated bench. Waste rock repositories are those facilities which have been constructed from the bottom up, by placing waste materials in successive lifts using selective waste rock handling procedures. All of the waste rock facilities at the Zortman Mine are dumps, including the OK, Alder Gulch and Ruby Gulch waste rock dumps, shown on Figure 2.5-1.

TABLE 2.5-5
SUMMARY OF ZORTMAN SOLUTION PONDS

Facility	Maximum Solution Capacity (10^6 Gallons)[1]	Solution In Storage (10^6 Gallons)[1,2]	Remaining Solution Capacity (10^6 Gallons)[1,2]	Operational Status	History
Process - Pregnant	4.78	3.39	1.39	Active	Used as a flow equalization and retention pond for the Zortman water treatment system.
Process - Barren	4.74	3.86	0.88	Active	
'82 Contingency	5.07	3.77	1.30	Active	
'85/'86 Contingency	--	--	--	Removed	
Ruby Gulch Sediment	0.35	--	--	Active	
Ruby Gulch Capture	1.0	0.0	1.0	Active	Part of the Zortman water treatment system
Ruby Gulch Contingency	6.0	0.0	6.0	Active	Part of the Zortman water treatment system
TOTAL	21.94	11.02	10.57		

Source:
1 ZMI Revised Application for Amendment to Permit 00096, January, 1995.
2 As of September 1, 1994.

Key to Types of Ponds
Pregnant (with gold) or Barren (w/o gold) - **Process**
For excess CN solution - **Storage**
Primarily, to collect acid drainage - **Capture**
For additional solution storage - **Contingency**
For stormwater collection - **Sediment**

TABLE 2.5-6
SUMMARY OF LANDUSKY SOLUTION PONDS

Facility	Maximum Solution Capacity (10^6 Gallons)[1]	Solution In Storage (10^6 Gallons)[2]	Remaining Solution Capacity (10^6 Gallons)	Operational Status	History
Process - Pregnant	4.96	3.54	1.42	Active	
Process - Barren 1	4.60	3.55	1.05	Active	Relined, 1993
Process - Barren 2	7.43	0	7.43	Inactive	Relined, 1994
Upper 91 Contingency and Capture	1.3	0.65	0.65	Active	Constructed, 1991
Lower 91 Contingency and Capture	1.6	0.8	0.8	Active	Constructed, 1994
85/86 Contingency[3]	1.0	1.0	0	Active	Constructed, 1986
87 Contingency/Capture	0.5	0.25	0.25	Active	Constructed, 1993
King Creek Sediment	5.0	0	5.0	Active	Constructed, 1994
87 Storage Pond A	--	--	--	Filled	Out of service; covered with ore
87 Storage Pond B	27.69	23.81	3.88	Active	Located on top of 87 leach pad; to be removed in 1995
TOTAL	54.08	31.05	23.03		

Source:
1 ZMI, 11-15-94 Memo to Woodward-Clyde (ZMI 1994b)
2 As of January 12, 1996 (Ryan 1996)
3 Also used to collect Gold Bug Adit discharge

Key to Types of Ponds
Pregnant (with gold) or Barren (w/o gold) - **Process**
For excess CN Solution - **Storage**
Primarily, to collect acid drainage - **Capture**
For additional solution storage - **Contingency**
For stormwater collection - **Sediment**

TABLE 2.5-7
SUMMARY OF WASTE ROCK FACILITIES
ZORTMAN MINE

Facility	Permitted Disturbance (in Acres)[1]	Existing Disturbance (in Acres)[1,2]	Permitted Load Capacity (Ton)[1,2]	Current Load (per cent of total)[1,2]	Operational Status
Zortman Waste Rock Dumps					
Alder Gulch Dump	16.0	16.4	3,365,000	100	Reclaiming
Ruby Gulch/ Sulfide Storage Dump	9.4	1.8	2,500,000	34	Reclaiming
OK Dump	8.0	6.8	1,235,000	100	Reclaiming
TOTAL	33.4	25.0	7,100,000	77	

Source:

1 ZMI, Revised Application for Amendment to Permit 00096, January, 1995.
2 As of January, 1996.

Table 2.5-7 provides a summary of the disturbances associated with these facilities. Approximately 33 acres have been disturbed for waste rock storage, and all three dumps have been fully loaded to their permitted capacity. The Alder Gulch and OK dumps have had surface reclamation, while the Ruby Gulch dump is being reclaimed at this time. A description of the reclamation status for each dump is provided in Section 2.5.2.5.

Two dumps and one repository have been used for the disposal of most of the waste rock generated at the Landusky Mine, although several much smaller sites have also been used to dispose waste rock. Table 2.5-8 provides a summary of the major disturbances associated with the Montana Gulch dump, the Mill Gulch dump, and the Gold Bug repository. These facilities are also shown on Figure 2.5-1. Approximately 171 acres have been disturbed for waste rock disposal (although the Gold Bug repository uses existing mine pit disturbance). The Montana Gulch dump, constructed in 1982, has been loaded to its permitted capacity of approximately 8 million tons over a disturbance area of approximately 22 acres. The Mill Gulch dump, which first began loading in 1988, was originally anticipated by ZMI to hold approximately 35 million tons of waste rock, but the agencies prohibited further placement of waste rock in this facility because of problems with acid drainage (DSL/BLM 1993a,c; DSL/BLM 1994a). No more waste rock is scheduled to be placed on the Mill Gulch dump, which contains approximately 17 million tons of material and covers about 63 acres of disturbance. Since the agencies prohibited use of the Mill Gulch dump, waste rock generated at the Landusky Mine has been loaded as backfill into the Gold Bug pit. As of September 1994, this repository contained about 14 million tons of waste rock. In addition, about 2 to 3 million tons of waste rock has been used to backfill the lowest portions of the Queen Rose pit to provide a free-draining pit floor. About 6.5 million tons of waste rock were used in leach pad and buttress construction. A description of the reclamation status for each dump is provided in Section 2.5.2.5.

2.5.1.5 Other Features and Facilities

This section describes other important features and facilities at the mines. Tables 2.5-9 and 2.5-10 show the disturbance areas and operational status for some of these support facilities.

Office/Laboratory Facilities

The main office building for Zortman Mining, Inc. is located in the town of Zortman. The main office houses mine management, engineering, geology, environmental, safety, accounting and payroll personnel. Employee parking is provided adjacent to the building. A permitted septic system is dedicated to the office building.

The production assay lab is located across from the main office in a separate building. A sample of blasthole rock cuttings from the mine are brought to the assay lab to determine gold content by cyanide dissolution and atomic absorption assay of the cyanide solution. Additionally, 1 in every 30 samples are fire assayed to determine total gold content and used as a check assay to ensure the cyanide assay is correct. Every third blasthole sample is checked for total sulfur content using a Leco furnace assay. Ventilation hoods are provided over chemical mixing, filtering and cyanide assay stations and vented to a caustic liquid fume scrubber that cleanses the exhaust air prior to release. Runoff solution from the scrubber is contained and collected in barrels and sent to a lined leach pad facility. Cupels from the assay lab are barreled and shipped to Asarco's East Helena smelter for disposal. All lab assay solutions and rock samples are collected and sent to a lined leach pad facility for disposal. Since there is not active mining at the Zortman Mine, virtually all lab work conducted at the laboratory supports existing operations at the Landusky Mine.

A research laboratory, offices, safety training room and record storage "annex" building is housed immediately west of the production lab. The research lab conducts gold extraction testing, acid base accounting and humidity cell testing for predicting ARD. Chemical mixing areas are ventilated and exhausted. Lab solutions and rock samples are collected and sent to a lined leach pad facility for disposal.

A light vehicle garage is also located adjacent to the production lab. ZMI's small vehicle fleet is serviced here. All spent fuel, solvents, oils and lubricants are collected and transported off site for recycling or disposal by an EPA licensed contractor. A heavy vehicle maintenance garage is located near the 82 leach pad.

Access and Haul Roads

The main access road to the Zortman Mine follows Ruby Gulch northwest from the town of Zortman. ZMI has received permission to move this road out of the streambed to the existing (but largely unused) county road on the east side of the Ruby drainage. This activity is scheduled to occur in 1996. The main access road

TABLE 2.5-8
SUMMARY OF WASTE ROCK FACILITIES
LANDUSKY MINE

Facility	Permitted Disturbance (in Acres)[1]	Existing Disturbance (in Acres)[2]	Permitted Load Capacity (Ton)[1]	Current Load (per cent of total)[2]	Operational Status
Landusky Facilities					
Montana Gulch Dump	27.5	21.3	8,000,000	100	Reclaiming
Mill Gulch Dump	70.0	63.1	17,000,000	100	Reclaiming
Gold Bug Repository	86.4[3]	86.4[3]	18,000,000	89	Active
TOTAL	183.9	170.8	43,000,000	95	

Source:

1 Revisions to Landusky Operating Plan, July, 1995 (ZMI 1995a)
2 As of January 12, 1996 (Ryan 1996)
3 Duplicates pit disturbance

TABLE 2.5-9
PLANT AND STORAGE AREAS - SUMMARY OF CURRENT CONDITIONS
ZORTMAN MINE

Facility	Disturbance Area in Acres[1]	Volume of Soil (Cubic Yards)[2]	Operational Status
'82 pad site soil stockpile	4.3	15,000	Inactive
'83 pad dike soil stockpile	1.0	0	Inactive
South Ruby Saddle soil stockpile	0.9	31,573	Inactive
North Ruby Saddle soil stockpile	3.2	135,833	Inactive
Mine Equipment	1.1	n/a	Active
Process Equipment	4.2	n/a	Active
Old Ruby Shop	0.4	n/a	Inactive
Process Plant/Refinery	2.0	n/a	Active
TOTAL	17.1	182,406	

Source:

1 ZMI Revised Application for Amendment to Permit 00096, January, 1995 (ZMI 1995b).
2 Annual Progress Report for Operating Permit 00095, June, 1994.

TABLE 2.5-10
PLANT AND STORAGE AREAS - SUMMARY OF CURRENT CONDITIONS
LANDUSKY MINE

Facility	Disturbance Area in Acres[1]	Volume of Soil (Cubic Yards)[2]	Operational Status
Mill Gulch Soil Stockpile	10.1	1,479,265	Active
August/Little Ben Soil Stockpile	5.4	436,568	Active
Gold Bug Soil Stockpile	2.2	75,020	Active
Montana Gulch Soil Stockpile	2.0	180,532	Active
Montana Gulch Maintenance Area	4.5	n/a	Active
Process Plant	26.0	n/a	Active
TOTAL	50.2	2,171,385	

Source:

1 Draft Revisions to Landusky Operating Plan, April, 1995 (ZMI 1995a)
2 Annual Progress Report for Operating Permit 00096, June, 1994

and other haul and mine access roads are depicted on Figure 2.5-2.

The Landusky Mine can be accessed from a few roads, but the primary (restricted) access is the gravel road east from the town of Landusky, or from the road connecting the Zortman and Landusky mines. Another access road leading to the mine is up the Mission Canyon from Hays, which is located north and west of the Landusky Mine. The Landusky Mine access roads and other haul roads are also shown on Figure 2.5-2.

Power and Water Supply

A 1500 kV line supplies electrical power to the process plant and mine facilities at the Zortman Mine. This power is obtained from the Zortman grid. For the Landusky Mine, electrical power is obtained from the Landusky grid, which is supplied by the Big Flat Power Cooperative through an existing 23 kV line.

Process water is obtained from precipitation and groundwater appropriation. Current water appropriation for the Zortman Mine is permitted by a groundwater appropriation issued by the Department of Natural Resources and Conservation. The appropriation for this permit includes the beneficial use of 530 acre-feet (175 million gallons) of water at 500 gpm during the period of March 1 through November 30 each year. The appropriation is for groundwater as well as net inflows from direct precipitation and surface water runoff/runon. At present, water for mine operations is supplied by two production wells (ZL-102 & ZL-163) located near the Zortman water treatment plant (see Exhibit 1). Water is consumed at the project site by ore wetting, spray evaporation, and haul road watering to control dust.

At the Landusky Mine water is consumed at the project site by ore wetting, spray evaporation and haul road watering. Fresh water makeup is accomplished through storage of precipitation on the leach pad and water appropriation from the Gold Bug Adit drainage (250 average gallon per minute flow) and a groundwater appropriation of 90 gpm issued by the DNRC (see Figure 2.5-4). The average makeup water required is 260 gpm, of which 55 gpm is for road watering.

Sewage Treatment

The production lab, "annex" building, and main offices located in Zortman each have septic systems for human waste. Separate septic systems are also in place at the processing plants and maintenance buildings for both mines.

Construction Materials

ZMI has used waste rock in the construction of facilities during its sixteen year history of mining, thereby eliminating the need for development of a gravel pit or quarry. For instance, waste rock has been used to construct leach pad retaining dikes, and old mill tailing has been used in the construction of leach pad liner covers and for road base. Waste rock material used in containment dikes typically has ranged in size from one foot to gravel or pea sized. Other construction materials include cover soil and clay.

Cover Soil Stockpiles

Existing cover soil stockpiles are located as shown on Figure 2.5-1, with storage volumes previously presented on Tables 2.5-9 and 2.5-10. Cover soil stockpiles have been developed by salvaging available topsoil as areas are disturbed during construction of new facilities.

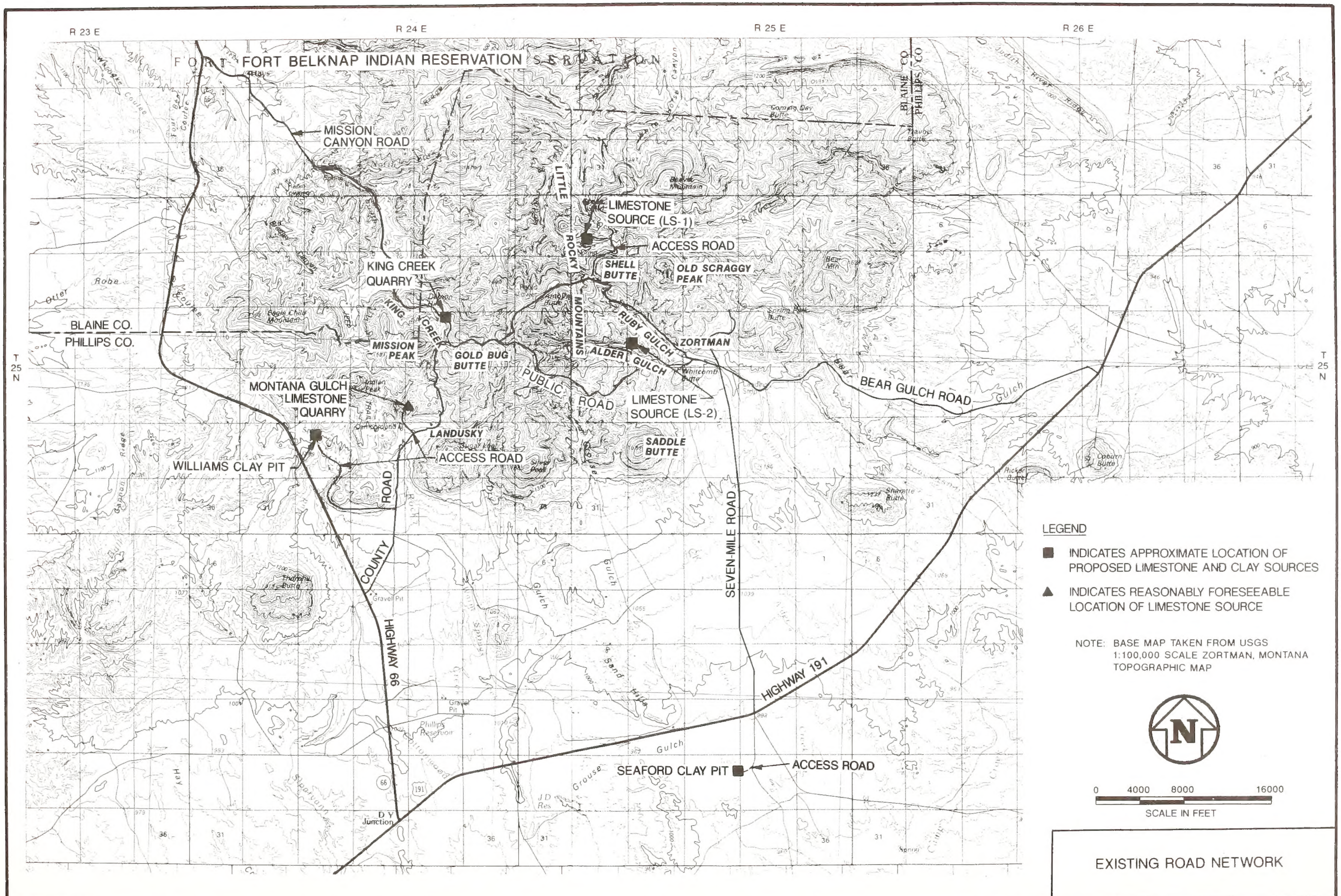
Clay Borrow

Under permits issued by the DEQ (formerly the Department of State Lands, Open Cut Bureau) clay for leach pad and process pond liner construction at the Zortman Mine has been obtained from clay pits near the mining operations. The Seaford Clay Pit is located approximately 7 miles south of the town of Zortman as shown on Figure 2.5-2. The pit has been developed using highwall mining methods. Current disturbance is approximately 4.2 acres. Another clay pit, located near the old Zortman landfill, was also used to provide materials for leach pad construction.

Clay borrow for leach pad and process pond liner and reclamation cover construction at the Landusky Mine is obtained from the Williams Clay Pit, located approximately 2 miles west of the town of Landusky, as shown on Figure 2.5-2 The clay pit has been developed using highwall mining methods. Current disturbance is approximately 26 acres, although some of this has been reclaimed.

2.5.1.6 Water Management

This section presents an overview of water management plans prepared by ZMI to mitigate water quality impacts from mine facility discharges. It includes a description of measures that have been or would be implemented for management of process waters, storm waters and mine drainage. This section is divided into discussions on surface water runoff control, water capture, water treatment and land application disposal (LAD). Additional detail on measures to improve and maintain water quality is contained in the Water Quality Improvement Plan, which is in Appendix A.



EXISTING ROAD NETWORK

FIG. 2.5-2

Objective: The objective under this and all other alternatives is to protect beneficial use, and to achieve and maintain compliance with water quality standards.

Approach: This alternative relies heavily upon capture and treatment of impacted waters. Only minimal effort is made to limit infiltration of precipitation into mine waste that may generate undesirable effluent. Moderate reliance is placed upon preventing run-on of storm water into mine waste units and ore processing facilities through construction of storm water diversions and conveyances.

Some of the existing waste and ore leaching facilities at the mines are generating acid drainage (see Section 3.2.2 for a discussion of ARD and impacts to water resources in the vicinity of the two mines). Field inspections conducted by DSL and BLM in 1992, and a review of water quality monitoring data showed that ZMI's operating and reclamation plans were not preventing ARD from several of the mine facilities, including waste rock dumps and ore heap retaining dikes. As a result, DSL and BLM prepared a Supplemental EA in November, 1993 to evaluate ZMI's proposed modifications to the mine plan to address problems associated with ARD.

Improvements and modifications were made to the Landusky Mine water control and capture systems as required by the March, 1994 Decision Record for ARD Control and Remediation (DSL/BLM 1994a). Some of the significant requirements of that decision for water control included:

- Improvements to the efficiency and size of the ARD capture and pumpback systems in Sullivan Creek and Mill Creek, including the installation of slurry cut-off walls, increased pumpback capacity, and resizing surge ponds for storm events.

- Construction of drainage or runoff control structures within the mine permit boundary to prevent storm water from contacting acid forming materials, or from disturbing reclamation efforts.

- Enhancement of the water quality monitoring, reporting, and interpretation program.

- Installation of interim composite reclamation covers on the Mill Gulch and Gold Bug Butte waste rock facilities to limit water infiltration and contact with acid forming materials. In addition, the 91 leach pad dike was resloped and capped with a composite reclamation cover.

Surface Water Runoff Control

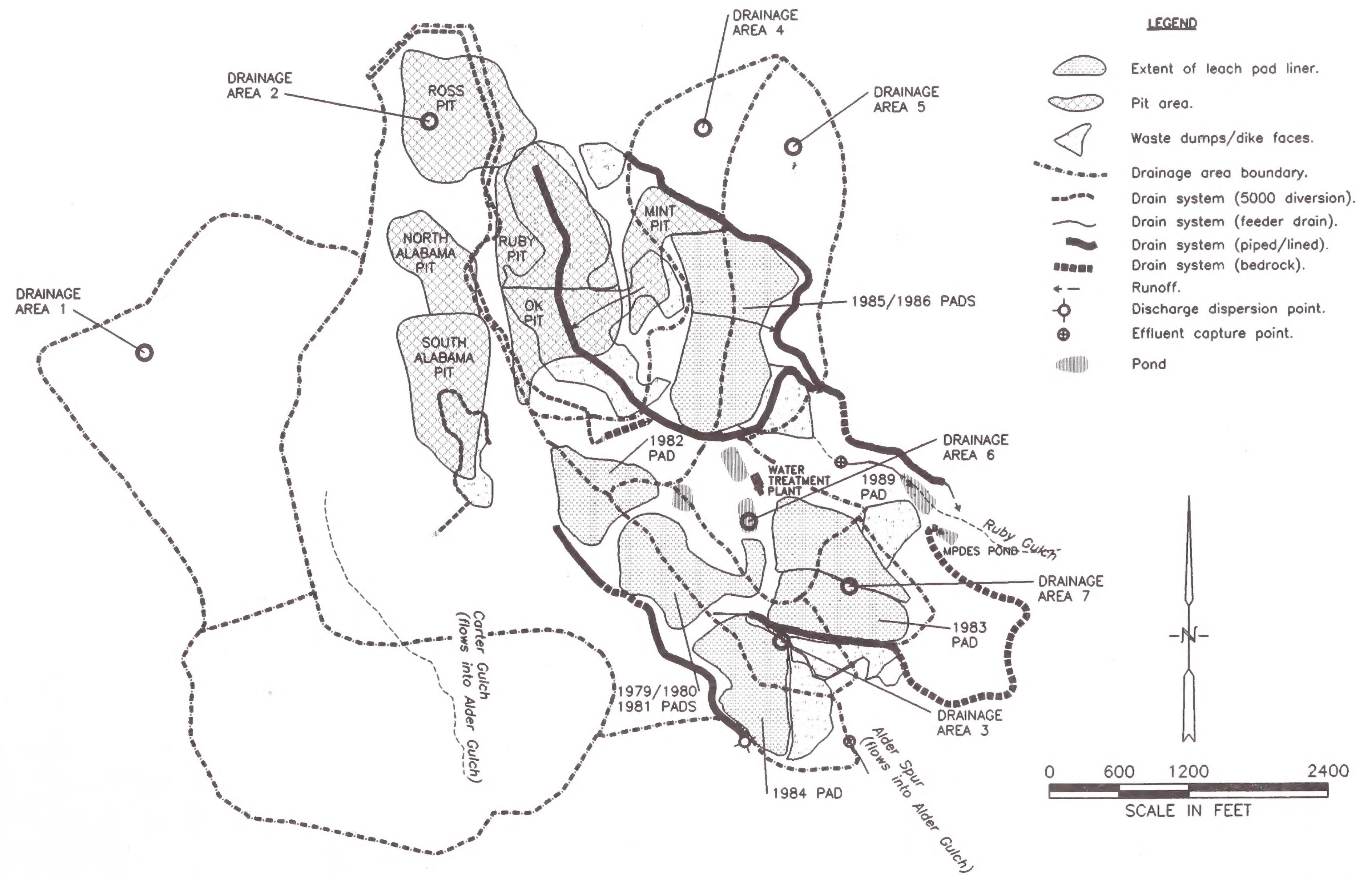
Interim drainages have been constructed throughout the mining area to route storm water and runoff around the pit complex, leach pads and waste dumps. These interim drainages were built to meet immediate needs of ARD control. As such, they were not intended to deal with flows in excess of a 10-year, 24-hour storm event of 2.5 inches. Current permit requirements at the Landusky Mine are that diversion drains around critical facilities (waste rock dumps and ore heaps) be sized to convey runoff from a 6-inch, 24-hour storm event at mine closure. Drains carrying storm water are routed to dispersion points consisting of coarse rock filters or sediment control ponds that overflow into natural drainages. Figure 2.5-3 and Figure 2.5-4 illustrate locations of bedrock drains and lined drainage channels. The lined drainage channels consist of 6 to 12 inches of compacted clay, overlain by 10-mil PVC liner, 5 ounces of geotextile and 6 to 12 inches of run of mine waste. Bedrock ditches are V-shaped and lined channels are trapezoidal. Maintenance consists of removal of sediment buildup and repositioning of rip rap when necessary.

<u>Zortman Mine Pits</u> - The current pit configuration has bedrock diversions constructed to the east and west to route storm water away from the pits. Standing water does not develop in the pits.

<u>Landusky Mine Pits</u> - Diversions have been constructed to route storm water away from pit disturbance limits. Water within the pit disturbance area and associated haul roads is collected in the pit. Because the Gold Bug and Queen Rose pits are being backfilled as part of the current mining operations, only the August/Little Ben portion of the pit would remain as an internally draining basin.

When mining operations are completed, runoff from within the Queen Rose/Suprise, and August/Little Ben pits would flow to the bottom of the August pit then out through the August tunnel, an historic adit from upper Montana Gulch. Flow entering the tunnel from the pit drainage would discharge beneath the Montana Gulch waste rock dump, seep through the dump, and surface near monitoring site L-38 (see Exhibit 2). This water would then enter the 85/86 leach pad underdrain, ultimately resurfacing near the discharge point of the Gold Bug tunnel in Montana Gulch.

<u>Leach Pads</u> - Diversions drainages are constructed around the leach pads to prevent the inflow of storm water. The process solution circuit is a closed system subject only to direct precipitation and evaporation. As a minimum, the process circuit is sized to contain the



EXISTING ZORTMAN MINE DRAINAGE PLAN: INDICATES CURRENTLY PERMITTED EXISTING LOCATIONS FOR WATER HANDLING, CAPTURE AND TREATMENT FEATURES

SOURCE: ZORTMAN MINING INC., 10/94

EXISTING ZORTMAN MINE DRAINAGE PLAN

FIG. 2.5–3

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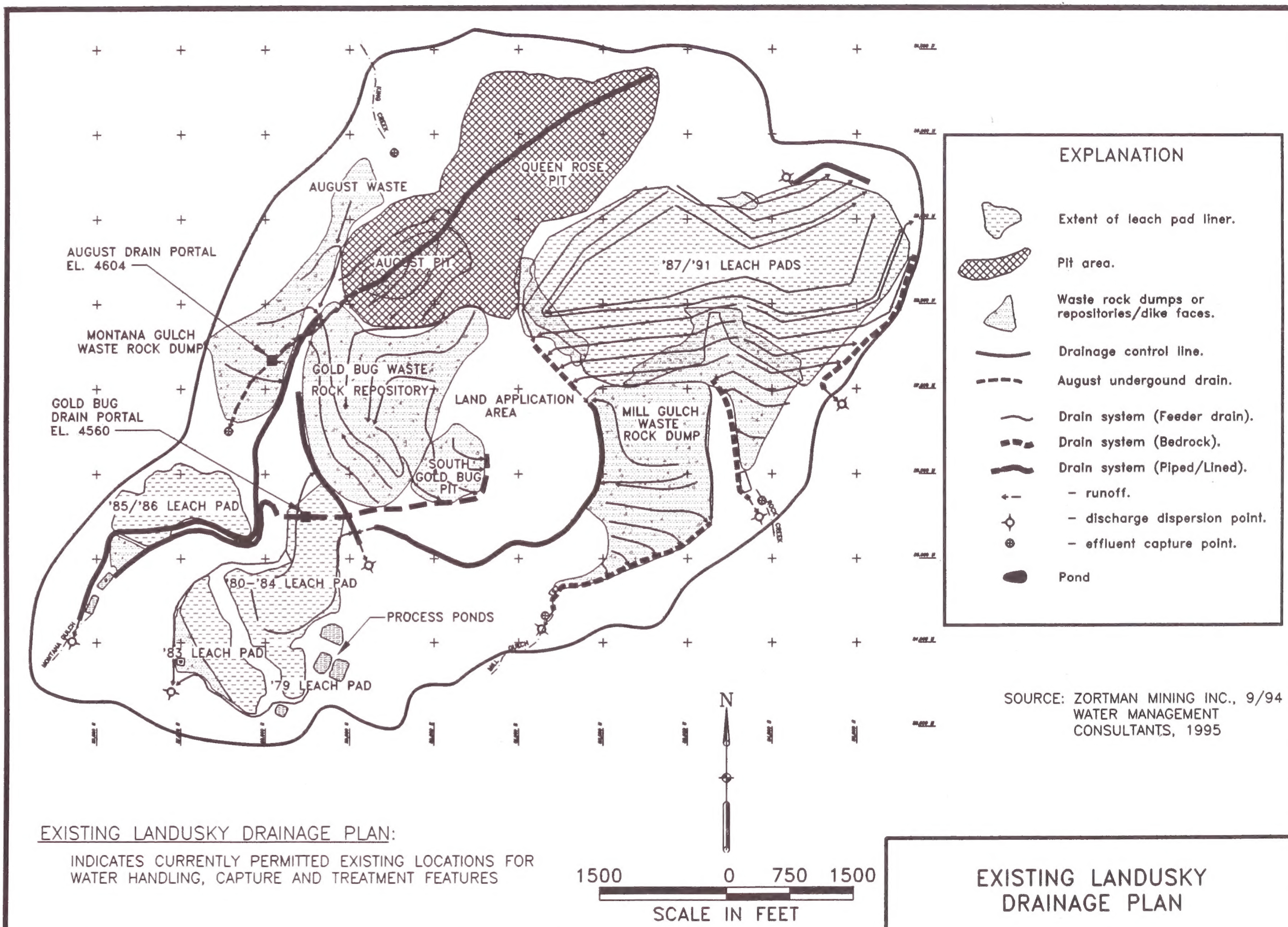


EXISTING LANDUSKY DRAINAGE PLAN:

INDICATES CURRENTLY PERMITTED EXISTING LOCATIONS FOR WATER HANDLING, CAPTURE AND TREATMENT FEATURES

EXISTING LANDUSKY DRAINAGE PLAN

FIG. 2.5-4

173E0012

direct precipitation from a 100-year, 24-hour storm event in addition to the drain down volume of any leaching solution in circulation.

Alder Gulch Waste Rock Dump - Diversions are constructed to the north and northeast of the Alder Gulch waste rock dump to divert storm water around the dump. The diversions are lined to prevent ditch flow from infiltrating into the waste rock dump. Three 25-foot wide drainage benches at 4,940, 4,800, and 4,625 foot elevations remove direct precipitation off the dump surface.

Mill Gulch Dump - Stormwater control for the Mill Gulch dump was implemented by several techniques: direct run-on is prevented; dozer basins are used to slow water and collect sediment; erosion control benches have been lined to direct runoff to main drainage diversion ditches; a 36-inch capillary break was placed under the cover soil to convey sub-surface water; and, revegetation will take place with a mulch and tackifier base. If erosion occurs during the first season of revegetation the following steps will be taken to ensure that the erosion does not reach the clay barrier: regrading of the wash, revegetation and placement of erosion control matting in the wash area, and/or straw bale placement for velocity control and sediment trap.

In an effort to reduce the volume of acidic seepage emanating from the toe of the Mill Gulch waste rock repository, surface reclamation has been implemented to limit water infiltration. Drainage ditches are 10-15 feet wide, 2 feet deep, on a 1-3 percent grade and have been constructed in 4-5 feet of capillary break material. These drainage ditches are lined with a synthetic barrier, covered with a geotextile, and held in place with 6 inches or more of non-acid generating material. Drainage ditches have been designed for runoff from the 6-inch, 24-hour event. A synthetic impermeable barrier has been placed at the clay/capillary break interface and covered with a geotextile to serve as a substrate drain. The lateral drain on the east side of the dump will handle flow velocities of greater than 5 feet/second Bedrock drainage ditches built for flow velocities greater than 5 feet/second were constructed using drill and blast techniques to shape the channel. After the channel had been shaped it was cleaned to prevent piping, sediment transport, and debris buildup that could lead to damming.

Gold Bug Waste Repository - All primary storm water drains at the Gold Bug repository are expected to remain functional for a number of years following completion of mining operations. Final drain designs would accommodate the 6-inch, 24-hour storm event with an additional built-in safety factor.

The Gold Bug waste rock repository is constructed with intermediate benches to route storm water away from the active waste disposal area and into Montana Gulch. Benches are placed every 100 vertical feet to keep drainage off the main repository face and control soil erosion. Benches are from 15 to 30 feet wide and sloped back into the repository at grades of 5 to 10 percent. These benches have been capped with clay or synthetic liner in a similar manner to the main portion of the repository. A drainage ditch was constructed at the intersection of the bench with upslope portion of the repository. This ditch was lined with a synthetic impermeable barrier, which is held in place with blue waste rock at least 6 inches in size. The drainage ditches convey runoff from the reclaimed repository and onto sideline ditches. These ditches are 2 feet deep and 4 feet wide and have grades which vary from 33 to 50 percent. The liner for these ditches is a synthetic impermeable barrier bedded upon 6 inches of clay to gravel sized natural material. The liner was secured in place with at least 6 inches of blue waste material.

Drains carrying storm water are routed to dispersion points (ponds, or coarse rock filters). Mine discharges are routed to contingency ponds (500,000-1,500,000 gallon ponds with associated pumping equipment), and added to the process circuit. Most drainage channels are lined with 6 to 12 inches of compacted clay, overlain by 10-mil PVC liner, 5 ounces of geotextile fabric such as Trevira 1120, and 6 to 12 inches of run of mine waste rock.

Montana Gulch Waste Dump - The Montana Gulch waste rock dump has a diversion ditch to the east for storm water. The tops of the waste rock dumps at the head of King Creek are graded to drain away from King Creek and into Montana Gulch.

Water Capture

Three water capture systems have been installed at the Zortman Mine to capture water that has been impacted by contact with acid generating materials. These are located at Ruby Gulch, Alder Spur, and Carter Gulch below the Alder Gulch waste rock dump. The capture systems consist of lined sumps located in the drainage below each facility. Water captured from the dumps is gravity fed or pumped through insulated pipes to holding tanks. When a holding tank reaches capacity water is pumped, via a pipeline, to the 4-million-gallon Zortman water treatment plant flow equalization pond. Figure 2.5-3 shows locations of capture systems and the water treatment plant. Seepage capture ponds and sumps are inspected on a weekly basis.

At the Landusky Mine, seepage is collected in the Sullivan Creek and Mill Gulch drainages using capture ponds and collection sumps (see Figure 2.5-4). Water from the collection sumps is pumped to a capture pond. Captured water is pumped, untreated, via pipeline to the 87 leach pad for use as process makeup water. Water from the Gold Bug adit is collected in Montana Gulch and aerated in the 85/86 contingency pond to precipitate iron. Water is then evaporated or released through the pond's spillway.

Additional information concerning the capture systems is in the Summary of the Water Quality Improvement Plan, Appendix A. A brief description of the water capture systems follows.

Ruby Gulch - Ruby Gulch drains most of the eastern portion of the Zortman mine site. Impacted water is currently captured in temporary sumps and holding tanks, pumped to the Zortman mine water treatment plant, and treated using a lime-precipitation treatment process. Treated water is returned to Ruby Gulch below the capture sumps. A 7-million-gallon capacity pond for capture of Ruby Gulch headwall seepage was constructed and completed in 1995 after being permitted by the Corps of Engineers. The pond has been sized for a flow rate from a 100-year, 24-hour storm event (6.3 inches). Slurry cutoff walls above the pond are used to ensure groundwater along the bedrock interface is collected and routed into the pond. V-shaped diversions sized for the 6-inch, 24-hour event are constructed around the edge of the pond to route storm water away from the ponds. The pond will require little maintenance as storm water will be diverted around it. Maintenance of the diversion ditches would include removal of sediment buildup and repositioning of rip rap as required.

Old mine tailing within this portion of the Ruby drainage which may contribute to water pollution has been removed and stockpiled until it can be disposed in a waste rock repository or used as backfill in the mine pit.

Alder Spur - Alder Spur originates below the 83 and 84 leach pads' dikes. Seeps and flows from the pad underdrains are currently captured and pumped back to the Zortman mine water treatment plant. Treated water is then released to Ruby Gulch. The pumpback system is sized to collect and pump back a 10-year, 24-hour storm event. The pumpback system consists of a holding tank and a lined capture sump. Capture seepage flow averages less than 10 gallons per minute. Storm water is diverted away from the seepage capture points with a V-shaped ditch. Maintenance of the pumpback system includes regular inspection of the pumps, sumps, capture tank and pipelines to ensure complete capture.

Carter Gulch - The Alder Gulch waste rock dump is located on the east fork of Carter Gulch. This dump surface was reclaimed in October 1992. Seepage water from beneath the waste rock dump is captured and pumped back to the Zortman water treatment plant. Treated water is released to Ruby Gulch. The pumpback system is sized to collect and pump back seepage from a 10-year, 24-hour storm event. The pumpback consists of a holding tank and lined capture sumps. Capture seepage flow averages less than 10 gallons per minute, although runoff from large storm events have overwhelmed this system in the past.

Lodgepole Creek - No water management controls have been constructed in Lodgepole Creek drainage basin. Storm water is managed at the mine facilities to prevent discharge to this drainage.

Sullivan Creek (Headwaters of Rock Creek) - The headwaters segment of Rock Creek downstream of the 91 Pad is called Sullivan Creek. A series of staged collection points have been constructed. The first capture unit is recovery well EN-904 located at the buttress toe (see Exhibit 2). This well captures low pH seepage. Impacted water is pumped to a contingency pond at the toe of the leach pad dike. Another 1.3-million-gallon pond was constructed in the spring of 1994 below this pond to capture seepage when the buttress for the 87/91 leach pad expansion is constructed over the original pond. A second capture sump and pumpback tank was constructed downgradient of the 94 pond. Pumpback in this sump is conducted on an intermittent basis, depending on seepage pH. Captured waters are pumped to the 87 leach pad. The ponds capture and store (prior to pumpback) average seepage water flow of 20 gallons per minute. Maintenance requirements for the ponds are minimal as storm water is routed away from the pond area.

Mill Gulch - In 1988 the Mill Gulch waste rock dump was started below the 87 leach pad's dike, which is located at the head of Mill Gulch. Water flowing from the toe of the dump comes from seepage present beneath the dump. A collection gallery with slurry cutoff walls which diverts shallow surface water into the contingency pond at the toe of the waste rock dump. A seepage capture pond and downstream sump collect impacted waters which are pumped to the 87 leach pad. The Mill Gulch capture pond capacity is approximately 500,000 gallons and captures and stores (prior to pumpback) average seepage water flow of 40 gallons per

minute. Seepage is captured on an intermittent, as-needed basis when pH falls below 6.0. Maintenance requirements for the ponds are minimal as storm water is routed away from the pond area.

Montana Gulch - The Montana Gulch waste rock dump, 85/86 Pad, Gold Bug Adit and August Adit are located in the upper reaches of Montana Gulch. The 83 heap leach pad is located at the head of the second ephemeral gulch which enters into Montana Gulch downstream of the Gold Bug confluence. The 84 pad is located in the gulch containing the Gold Bug Adit. Flow from the Gold Bug Adit averages approximately 150 to 250 gallons per minute, most of which is used for road watering. Water from the Gold Bug Adit not used for road dust suppression is collected in a pipeline and routed to an aeration sprinkler in the 85/86 contingency pond, which precipitates iron. Water is then evaporated or released through the pond spillway into Montana Gulch. The precipitate is pumped onto a trench on the 85/86 leach pad. The 85/86 contingency pond capacity is approximately 1 million gallons. Maintenance requirements for the ponds are minimal as storm water is routed away from the pond area.

A 12-inch compacted clay barrier separates the upper Gold Bug waste rock repository from the lower repository at the 4,740 level. The barrier is inclined with a 2 percent grade to direct impounded water to the southwest where it can be collected, treated or placed in the process circuit if necessary.

King Creek - The pre-mining drainage of King Creek extended within the mine pit areas on the northern side of the mine. It also drains the northern portion of the Montana Gulch waste rock dump. This drainage once contained a large volume of tailing from historic mining operations, most of which were removed by ZMI. Pumpback facilities are being installed in the event water quality is impacted by mine activities.

Water Treatment

ZMI constructed a 2,000-gpm water treatment plant in May 1994 to treat seepage water captured at the toe of existing mine waste rock dumps at the Zortman Mine. The plant, located approximately 120 feet west of the refinery, operates at a rate of 200 to 2,000 gpm depending on factors such as precipitation amounts and seasonal operating conditions. Another water treatment plant is planned for the Landusky Mine and would be located in the Montana Gulch area. Appendix A contains additional detail on operation of the water treatment plant at the Zortman Mine.

Land Application Disposal

Provisions for land application disposal of process solution are required by the regulatory agencies for final heap draindown at mine closure, or in the case of an extreme precipitation event that overwhelms the capacity of the leaching circuit. In the land application process, leaching solutions are treated with either hypochlorite or hydrogen peroxide to detoxify the cyanide. All solutions must be at or below 0.22 mg/l WAD cyanide prior to land application. The treated solution is then sprayed over an undisturbed area using sprinkler irrigation. As the applied solution infiltrates, residual metals are adsorbed in the soil profile. Use of land application as a water management practice requires advanced notification and review by the regulatory agencies prior to each land application event to verify the character of the applied solutions, remaining soil attenuation capacity, and necessary monitoring techniques.

At the Zortman Mine, the Carter Butte land application area soil has been used during past emergency land application disposal in 1986-87. This area should not be used for additional land application due to metal loading and high salt content of the soil caused by these past events (Schafer and Associates 1993). A 205-acre land application area has been proposed for the Goslin Flats in the event land application would be necessary for Landusky or Zortman solutions disposal. At the Landusky Mine, 70 acres on Gold Bug Butte are permitted for land application of process solutions. This site may also be used for emergencies or disposal of final heap draindown solution.

Once land application is completed, soil samples are taken to determine the loading of the area soils by metals and salts from solutions. These results are used to determine if the area can be used again for land application, or if a new area should be made available for solution disposal.

2.5.1.7 Hazardous Materials

This section briefly describes the chemicals that have been or are currently used at the mines. A detailed discussion of hazardous material use, storage, handling, consumption, and waste is presented in Section 3.14.

A variety of potentially hazardous compounds are used in the mining, ore processing, and mine reclamation activities. The rate of use for these compounds has varied over the years, and some compounds have replaced others to increase operational efficiency or to accommodate operational modifications. For instance, petroleum-based solvents are no longer used at the

mine, having been replaced by a citrus-based solvent substitute.

Chemical use at the Zortman Mine is limited because there is no mining and little ore processing occurring. Most chemical use is associated with vehicle use and operation and maintenance of the water treatment plant.

The following table provides an estimate of the amount of each compound used at the Zortman operation.

Compound	Estimated Use
Lime	500 ton/yr
Flocculent	100 gal/yr
Gasoline	5,000 gal/yr
Hydrogen Peroxide	Contingency use
Oil and Lubricants	1,000 gal/yr
Antifreeze	500 gal/yr
Citrus-base Solvent	200 gal/yr

The Landusky Mine is currently producing and processing ore, so there are more chemicals used in greater amounts than at the Zortman Mine. The following table provides an estimate of the amount of each compound used at the Landusky operation.

Compound	Estimated Use
Lime	18,000 ton/yr
Zinc	110 ton/yr
Sodium Cyanide	1,750 ton/yr
Gasoline	5,000 gal/yr
Ca/Na Hypochlorite	Contingency use
Hydrogen Peroxide	Contingency use
Oil and Lubricants	80,000 gal/yr
Antifreeze	8,500 gal/yr
Citrus-base Solvent	800 gal/yr
Diesel Fuel	2.6 million gal/yr
ANFO	4,000 ton/yr
Anti-Scalants	8,200 gal

Lime is used for pH control at the water treatment plant at Zortman Mine. In addition, lime is used during mining operations to control the pH during the metal extraction process at the Landusky Mine.

Flocculent is used at the water treatment plant to help settle sludge out of solution at the Zortman Mine. Nalco 7852 is an aqueous solution of a polyquaternary amine used at the treatment plant.

At the Landusky Mine, flocculent is used to settle small particles out of the solution which create problems in the clarifiers in the metal extraction process. Percol 710 is an anionic polymer flocculent used in the ore processing plant.

Gasoline is used to power the mine's light vehicles. Light vehicles are fueled at both the ZMI office in Zortman and at the fuel farm at the Landusky Mine.

Hydrogen Peroxide is used at the end of mine life to destroy cyanide in heap leach rinsate solution if natural degradation of cyanide needs to be accelerated. An estimated 10,000 to 20,000 gallons of 70 percent hydrogen peroxide may be required at each mine, depending on the amount of natural degradation of cyanide compounds. Approximately 550 gallons of H_2O_2 are kept at the Landusky Mine.

Oil and Lubricants are used for lubrication of mine equipment. Oil products include rock drill oil, lubricant oils, hydraulic fluids, engine oils, and transmission fluids.

Antifreeze is an ethylene glycol used as engine coolant for the mine fleet.

Citrus-Based Solvent is a non-hazardous, citrus-based solvent for parts washing.

The following chemicals are used only at the Landusky Mine:

Diesel Fuel is used to power the mine vehicles.

Ammonium Nitrate is the main ingredient in the blasting agent "ANFO."

Sodium Cyanide is used to dissolve the gold and silver in the leaching process.

Hydrochloric Acid (HCl) at a molar concentration of 11 is used to remove scaling on the clarifiers, pump intakes, impellers, spray lines and return lines.

Calcium and Sodium Hypochlorite is used on a very infrequent basis to neutralize cyanide solution which may have leaked or spilled out of containment systems.

Anti-Scalants are used to prevent scaling around the pump intakes, and in the spray and return line.

2.5.2 Existing Reclamation Plans

This section describes ZMI's existing reclamation plans and procedures for the Zortman and Landusky mines. The information is based in large part on the Zortman Reclamation Plan and Post-Mine Topography (ZMI 1989), update to Operating Permit No. 00096, dated June, 1989; the Alternative Reclamation Plans for the Zortman Mining Area, dated January 1994 (ZMI 1994a); Application for Amendment to Existing Hard

Rock Operating Permit for Life-of-Mine Operation and Reclamation, No. 00095, December, 1989. In addition, a number of modifications to the reclamation plans and procedures for the Landusky Mine have been implemented since submittal of that application, as described in the environmental assessments and supplemental EA's dated May 11, 1990, January 25, 1991, and November 1993, including Decision documents implementing those actions.

The long-term reclamation objective is "... to establish a post-operation environment that is compatible with existing and proposed land uses of the Zortman area. On lands under the administration of the Bureau of Land Management, this will include returning disturbed areas to land uses consistent with those identified in the Resource Management Plan (ZMI 1989)." The specific post-operation land use objectives for the current reclamation plan include:

- Re-establishment of a biological potential suitable for supporting a vegetative cover appropriate to the area
- Permanent protection of air, surface water, and ground water
- Ensuring the protection of public safety and health
- Restoration of wildlife habitat
- Design of land configuration compatible with the watershed
- Reestablishment of an aesthetic environment providing visual quality and recreational opportunities

Table 2.5-11 and Table 2.5-12 illustrate the current reclamation schedule for the mines. Final reclamation of mine facilities is on hold pending completion of this EIS. The following sections describe the specific reclamation plans and actions which ZMI is currently permitted to implement for each disturbance area.

As a preface to the reader concerning reclamation plans and procedures, the term "reclaimed" is used to mean that reclamation procedures have been fully undertaken for a particular disturbance in accordance with *existing* permit requirements. However, no facility can be considered fully reclaimed until the agencies have certified that reclamation goals and objectives have been achieved, at which time ZMI's reclamation bond would be released. The agencies have not provided evaluations of final reclamation success for any disturbances and no reclamation bonds have been released.

2.5.2.1 Reclamation Materials

The current reclamation requirement for most mine facilities is to cover disturbed areas with 8 inches of topsoil, followed by revegetation. Because of concerns with acidic drainage in some areas, BLM and DEQ have required ZMI to immediately use more protective reclamation materials for three areas at the Landusky Mine: the Gold Bug waste rock repository, the Mill Gulch waste rock dump, and the 91 heap leach pad dike (DSL/BLM Decision Record 1994a). Under interim approval from the agencies, ZMI is using non-acid forming material in conjunction with clay and cover soil, to reduce surface water infiltration into these facilities. A description follows of the types of reclamation materials used.

Non-Acid Forming Waste

Waste rock with less than 0.2 percent total sulfur content is being used as part of the interim caps on the Mill Gulch waste rock dump and in the Gold Bug waste rock repository, and on the 91 heap leach pad dike. Waste rock used in these facilities comes from two sources: existing waste rock stockpiles, and waste rock generated by the ongoing mine operation. This waste rock has been determined by ZMI to have a low potential to generate acid. A definition of the waste rock types and waste rock characterization program is found in Section 2.5.1.1.

Limestone/Dolomite

Limestone and dolomite generated as waste rock during ore mining have been used on a limited basis due to availability at the Landusky Mine. Because of their high carbonate content, both of these rock types are useful to neutralize acidic conditions. Dolomite and limestone from outcrops within the mine permit area have most recently been used to provide a 3-foot buffering liner across the floor of the 4,640 bench in the Gold Bug waste rock repository.

Williams Clay Pit

Clay is used as a component layer of the interim caps which have been placed on the Mill Gulch waste rock dump and 91 leach pad dike. The swelling clay helps to reduce the possibility of moisture infiltration into the capped facilities. Clay used in Landusky Mine reclamation comes from the Williams clay pit located approximately 2 miles west of the town of Landusky. The clay is hauled by ZMI truck and loader fleet from the pit over the county road leading to the Landusky Mine, through the town of Landusky and onto the mine site to the area of final placement.

TABLE 2.5-11
ZORTMAN MINE RECLAMATION SCHEDULE[1]

Facility/Disturbance	Reclamation[2]
Heap Leach Pads	
79, 80/81	Reclaimed
82	1991
83	1992
84	1992
85/86	1994
89	1997
Dike Faces	
85/86	1988
82	1991
83, 84, 89	Reclaimed
Pit Floors (all)	1991
Waste Rock Facilities	
Ruby Gulch Waste Rock Dump	Reclaiming
Alder Gulch Waste Rock Dump	Reclaimed
OK Waste Rock Dump	Reclaimed
Process Plant	At Project Completion
Cover Soil Stockpile Sites	
82 Leach Pad Site	1991
83 Leach Pad Site	1992
South Ruby Saddle	1994
North Ruby Saddle	At Project Completion
Haul Roads/Access Roads	At Project Completion
Refinery Site	At Completion of Zortman and Landusky Projects
Storage Sites	
Mine Equipment Storage & Service	At Project Completion
Process Equipment Storage	At Project Completion
Old Ruby Shop Site	1991

[1] From Zortman Reclamation Plan and Post Mine Topography, June, 1989

[2] The term "reclaimed" is used to mean that reclamation procedures have been fully undertaken for a particular disturbance in accordance with *existing* permit requirements. However, no facility can be considered fully reclaimed until the agencies have certified that reclamation goals and objectives have been achieved, at which time ZMI's reclamation bond would be released. The agencies have not provided evaluations of final reclamation success for any disturbances and no reclamation bonds have been released.

TABLE 2.5-12
LANDUSKY MINE RECLAMATION SCHEDULE[1]

Facility/Disturbance	Final Reclamation[2]
Heap Leach Pads	
79	Already reclaimed
80/81/82	1989-90
83 & 84	1991
85/86	1996 to 1999
87	1999
91	2000
87/91	At project completion
Dike Faces and Ponds	
79 Pond	1996 to 1999
82 Pond	2001
83 Dike	1989
83 Pond	2001
84 Dike	1991
85/86 Dike & Pond	1996 to 1999
87 Pond	2000
91 Dike	1992
91 Pond	2001
Pit Floors (all)	Concurrent with Mining
Waste Rock Facilities	
Montana Gulch Dump	Already reclaimed
Mill Gulch Dump	In reclamation
Gold Bug Repository	Concurrent
Process Plant	At Project Completion
Topsoil Stockpile Sites	
Little Ben	1994
Mill Gulch Site	End of Project
Montana Gulch Site	1991
Gold Bug Site	End of Project
Haul Roads/Access Roads	At Project Completion
Refinery Site	Completion of Zortman and Landusky Projects
Storage Sites	
Mine Equipment Storage & Service	At Project Completion
Process Equipment Storage	At Project Completion

[1] From Landusky Life-of-Mine Plan, May, 1989

[2] The term "reclaimed" is used to mean that reclamation procedures have been fully undertaken for a particular disturbance in accordance with *existing* permit requirements. However, no facility can be considered fully reclaimed until the agencies have certified that reclamation goals and objectives have been achieved, at which time ZMI's reclamation bond would be released. The agencies have not provided evaluations of final reclamation success for any disturbances and no reclamation bonds have been released.

Cover Soil

The primary reclamation material used at the Zortman Mine is cover soil. A layer of cover soil approximately 8 inches thick is to be placed on all disturbed areas prior to revegetative seeding and planting. Cover soil is obtained from one of three stockpiles: the 82 leach pad site, the South Ruby Saddle stockpile, or the North Ruby Saddle stockpile. Approximate volumes of soil available at these stockpiles are shown on Table 2.5-9. Based on the estimated amount available in Zortman Mine stockpiles, a layer of cover soil approximately 4.0 inches thick could be used on all disturbed areas at the Zortman Mine which require reclamation topsoil. Supplemental topsoil from the Landusky Mine stockpiles could increase the cover thickness to approximately 8.0 inches.

Other materials used in reclamation include unconsolidated rock, scree, and soil above and below roadway cuts, which are incorporated into the regrading of haul and access roads.

At the Landusky Mine, cover soil is used on top of all mine disturbances, either as a final lift on the reclamation caps or as 8-inch layers directly overlying disturbed zones. Cover soil is obtained from one of four topsoil storage areas: the Mill Gulch stockpile, part of the Mill Gulch waste rock dump; the Little Ben soil stockpile; the Gold Bug soil stockpile; and the Montana Gulch soil stockpile. Approximate volumes of soil available at these stockpiles are shown on Table 2.5-10. Other, similar materials used for reclamation purposes would include unconsolidated rock, scree and soil above and below roadway cuts, which are incorporated into the regrading of haul and access roads.

2.5.2.2 Reclamation Testing and Covers

No geochemical testing is required of disturbance areas prior to reclamation, under terms of the existing mine permits. At the Zortman Mine, the only material to be placed on disturbance areas consists of 8 inches of cover soil. At the Landusky Mine, with the following exceptions, the "cover" placed on disturbance areas is limited to 8 inches of compacted cover soil. In March of 1994, ZMI was required to place more protective reclamation covers on the Mill Gulch waste rock dump and 91 heap leach pad dike, as well as on the waste rock dump which has been developed in the Gold Bug pit, with the understanding that these interim reclamation procedures may not suffice as a long-term mitigation. The two reclamation caps being used are designated Reclamation Covers B and C, as shown on Figure 2.5-5, and described as follows:

- **Reclamation Cover B** - Is used on fill slopes with grades greater than or equal to 5 percent which require a barrier cover. The sequence, from the lowest layer to the top, is:

Bottom:	24-36 inches of amended fill with <0.5 percent total sulfur content Two 6-inch lifts of compacted clay 36 inches of non-acid forming material as a capillary break 8 to 12 inches of cover soil
Top:	Revegetation with seed mixtures, fertilizers, and mulches

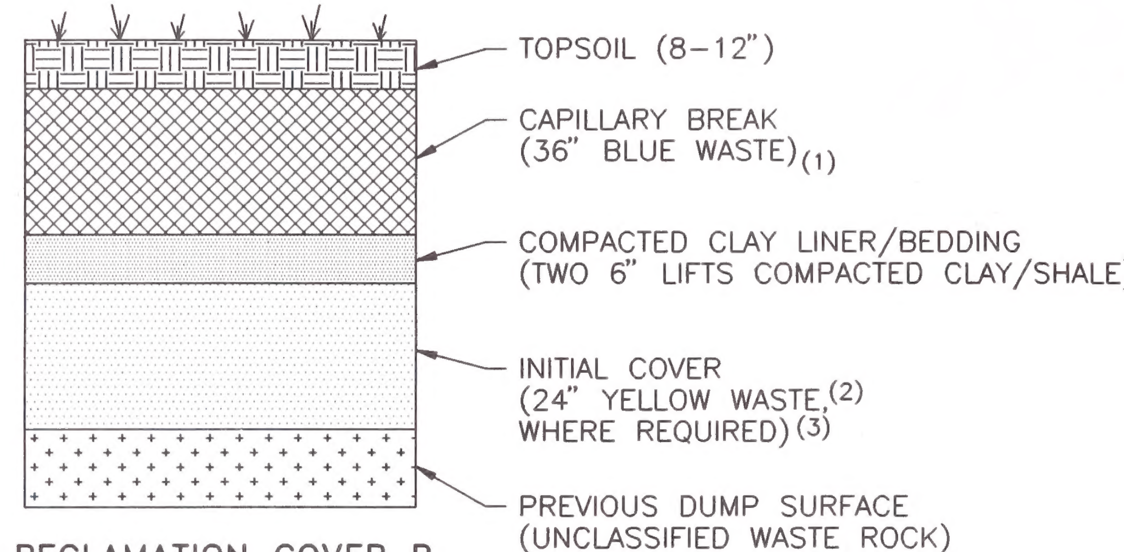
- **Reclamation Cover C** - Would be used on fill slopes of less than 5 percent that require a barrier cover. The sequence, from the lowest layer to the top, is:

Bottom:	24-36 inches of amended substrate with <0.5 percent total sulfur content 3 inches of compacted clay One layer of 15 to 20 mil PVC liner material One layer of 5 ounce geotextile material (to resist punctures in liner) 36 inches of non-acid forming material (capillary break) 8 to 12 inches of cover soil
Top:	Revegetation with appropriate seed mixtures, fertilizers, and mulches

2.5.2.3 Mine Pit Reclamation

For both mines, overall slope of the final pit walls would be approximately 45 degrees (1H:1V) with 30-foot-wide flat benches every 60 vertical feet. Pit floors would be sloped and graded to facilitate drainage and alleviate the accumulation of stagnant water. Where possible, pit floors are to be topsoiled and revegetated.

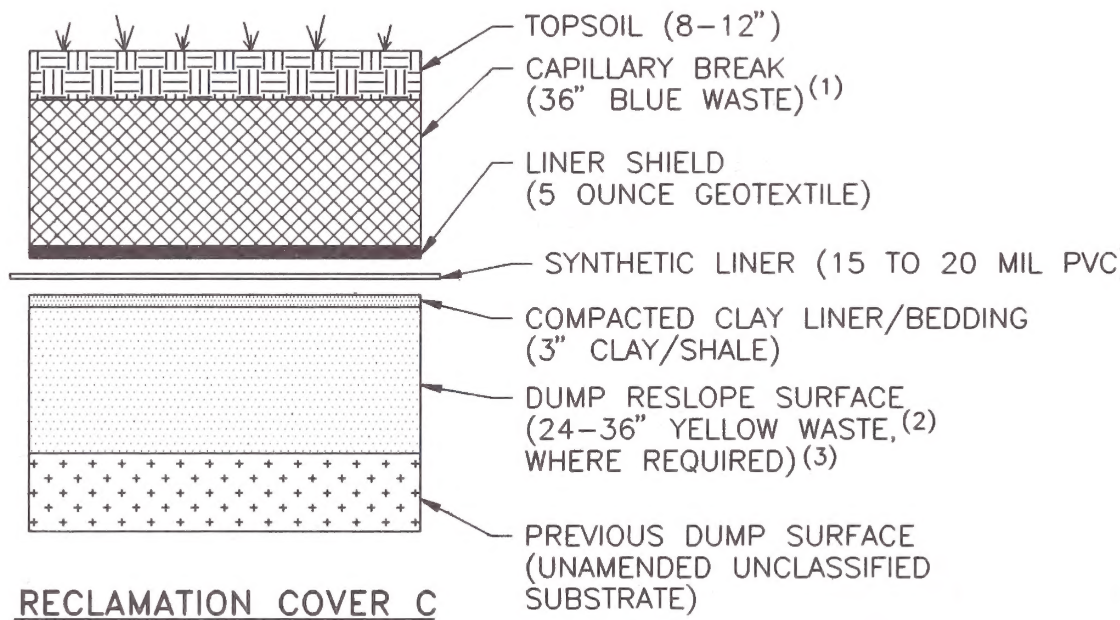
An existing permit requirement for the Landusky Mine is that, concurrent with mining operations, pit benches must be revegetated to the extent possible with soil and trees to reduce visual impact. Portions of the Gold Bug and Queen Rose pit are being used as a waste rock repository and are subject to reclamation requirements specific to waste rock repositories.



RECLAMATION COVER B

SLOPE COVER MILL GULCH
WASTE ROCK DUMP

SCALE: 1" = 4'



RECLAMATION COVER C

TOP COVER MILL GULCH
WASTE ROCK DUMP

SCALE: 1" = 4'

NOTES:

1. BLUE WASTE – LESS THAN 0.2% TOTAL SULFUR.
2. YELLOW WASTE – 0.2 TO 0.5% TOTAL SULFUR.
3. ONLY NECESSARY IF SUBSTRATE HAS MORE THAN 0.5% TOTAL SULFUR.

SOURCE: ZORTMAN MINING INC., 9/94

TOP AND SLOPE COVERS
MILL GULCH WASTE ROCK DUMP

FIG. 2.5–5

173E0001

2.5.2.4 Leach Pad Reclamation

Tasks associated with reclamation of the heap leach facilities include heap detoxification, surface reclamation, and liner perforation. The basic procedures associated with each of these tasks is described below, followed by a summary of the reclamation status for each heap leach facility at the mines.

Heap Detoxification

Detoxification of the spent ore on the leach pads begins when the amount of gold and silver collected in the leaching solution is no longer economically recoverable. The detoxification process consists of rinsing the ore on the heap leach pad with cyanide-free water to degrade the cyanide compounds left in the heap. The rinsing solutions are tested after flow through the heap to determine cyanide content and the rate at which detoxification is proceeding. If water rinsing is not successful, oxidizing agents such as hydrogen peroxide may be used to enhance cyanide breakdown. Figure 2.5-6 displays the steps followed in the heap detoxification process.

Heap detoxification continues until the solutions returning from the heap maintain less than 0.22 mg/l cyanide (measured as Weak Acid Dissociable or WAD cyanide) for a six-month period which includes a spring, high-flow surface runoff event. At that time the heap solutions remaining after detoxification are pumped to a holding pond and then to a land application area for final disposal.

Surface Reclamation

Either concurrent with or immediately after the heap leach pad is detoxified, surface grading begins to reduce pad slopes for revegetation. The existing general reclamation criterion for spent ore slopes is no steeper than 2H:1V with intervening benches every 200 feet of slope length. One exception is the Landusky 91 pad where 3H:1V slope with benches every 200 feet are required. Slope reduction is performed by track-mounted bulldozers pushing ore heap material from the facility crest or top down over the lift slopes, using cut and fill material from each of the heap benches to obtain the desired slope. Preparation for the site includes ripping of compacted areas on the top of the leach pad facility to reduce surface compaction and improve air and water movement through the surface, enhancing revegetation opportunity. However, ripping is not anticipated to be required for most areas on top of the heap since the leach pad is double-ripped during preparation for solution spraying. Leach pad crests, top and slopes are topsoiled and revegetated, as described in Section 2.5.2.8.

Containment dikes for the heap leach pads are constructed of waste rock valley fill at an overall slope of 2H:1V and have typically not been subject to further slope reduction since it would involve pushing material into the adjacent stream drainage. However, due to the acid forming character believed present in the Landusky 91 dike, the containment dike was required to be reduced to a 3H:1V slope to facilitate placement of enhanced reclamation covers (DSL/BLM 1994a). Dike faces are topsoiled and revegetated to blend with existing undisturbed contact zones and reestablish vegetation communities. Since reslope of dikes is generally not required, surface reclamation begins almost immediately after construction of the leaching facility.

Liner Perforation

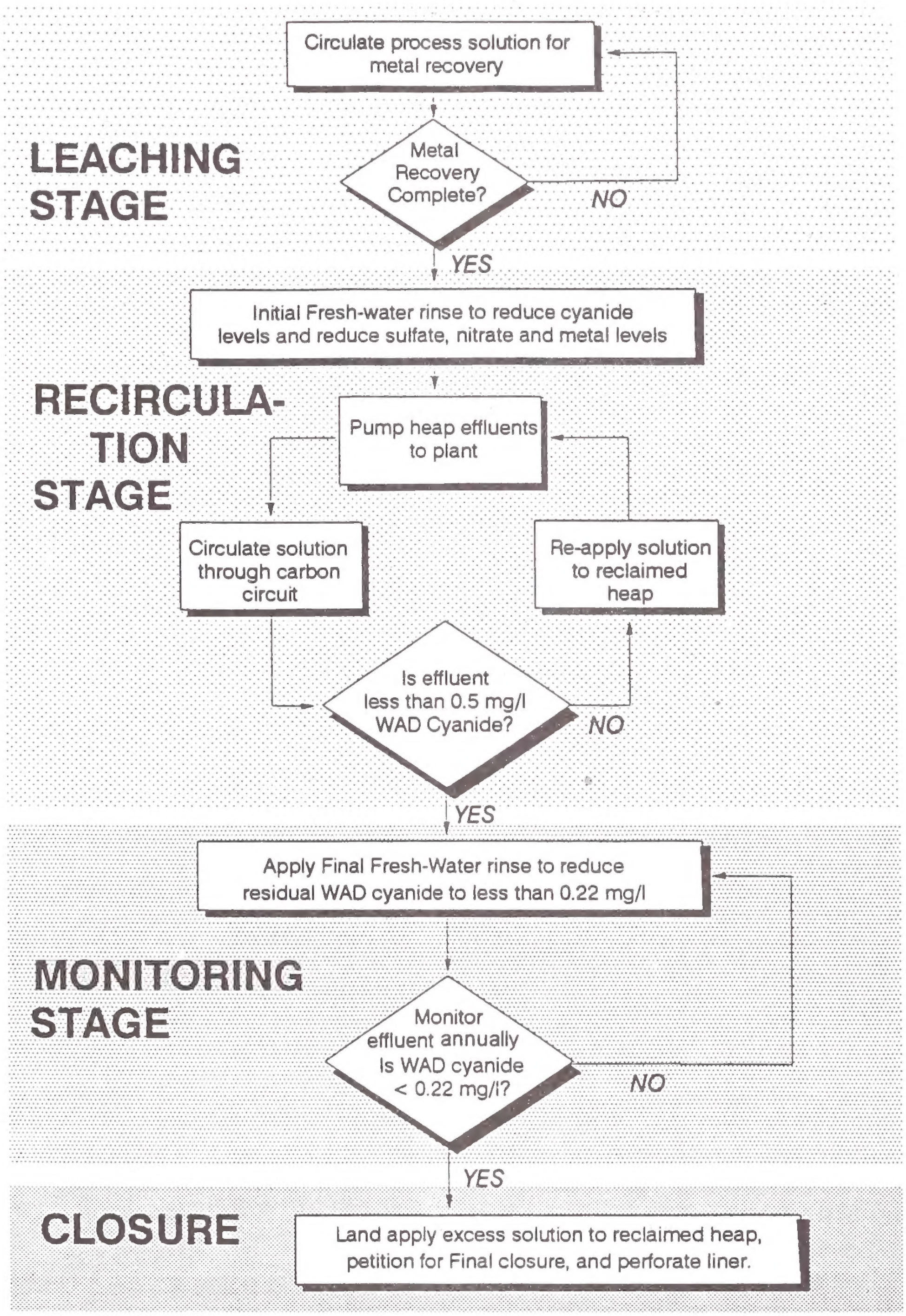
After the leach pad has been detoxified, the pad liner is perforated to reduce storage within the heap of precipitation and surface water runon. Approximately 3 to 4 drain holes, 6 inches in diameter, are drilled into the underlying drainage system to provide an exit for solution within the heap. Each perforation is backfilled with drain rock to an elevation of at least 5 feet above the liner surface to ensure continued drainage. The drain holes are positioned at the lowest elevation in the pad collection basin to provide for adequate drainage and prevent the formation of undesirable hydraulic conditions within the heap.

The exact number and location of these additional drain holes would be established in consultation with the agencies upon review of detoxification monitoring data. ZMI has committed to monitoring the leach pad effluent for a 10-year period prior to liner perforation so as to assure the quality of leachate reporting to the environment will meet water quality standards. To date, no leach pads have been perforated at either mine.

Leach Pad Reclamation Status

Reclamation as required by the existing permits is shown on Figure 2.5-7 and Figure 2.5-8 and described below. As of the time this EIS was prepared, none of the reclamation bond held for the facilities discussed below had been released.

Zortman 79 Leach Pad - The 79 leach pad was reclaimed in 1989. Topsoil from the South Ruby Saddle stockpile was spread 8 to 12 inches deep and was dozer tracked for seedbed preparation. The site was



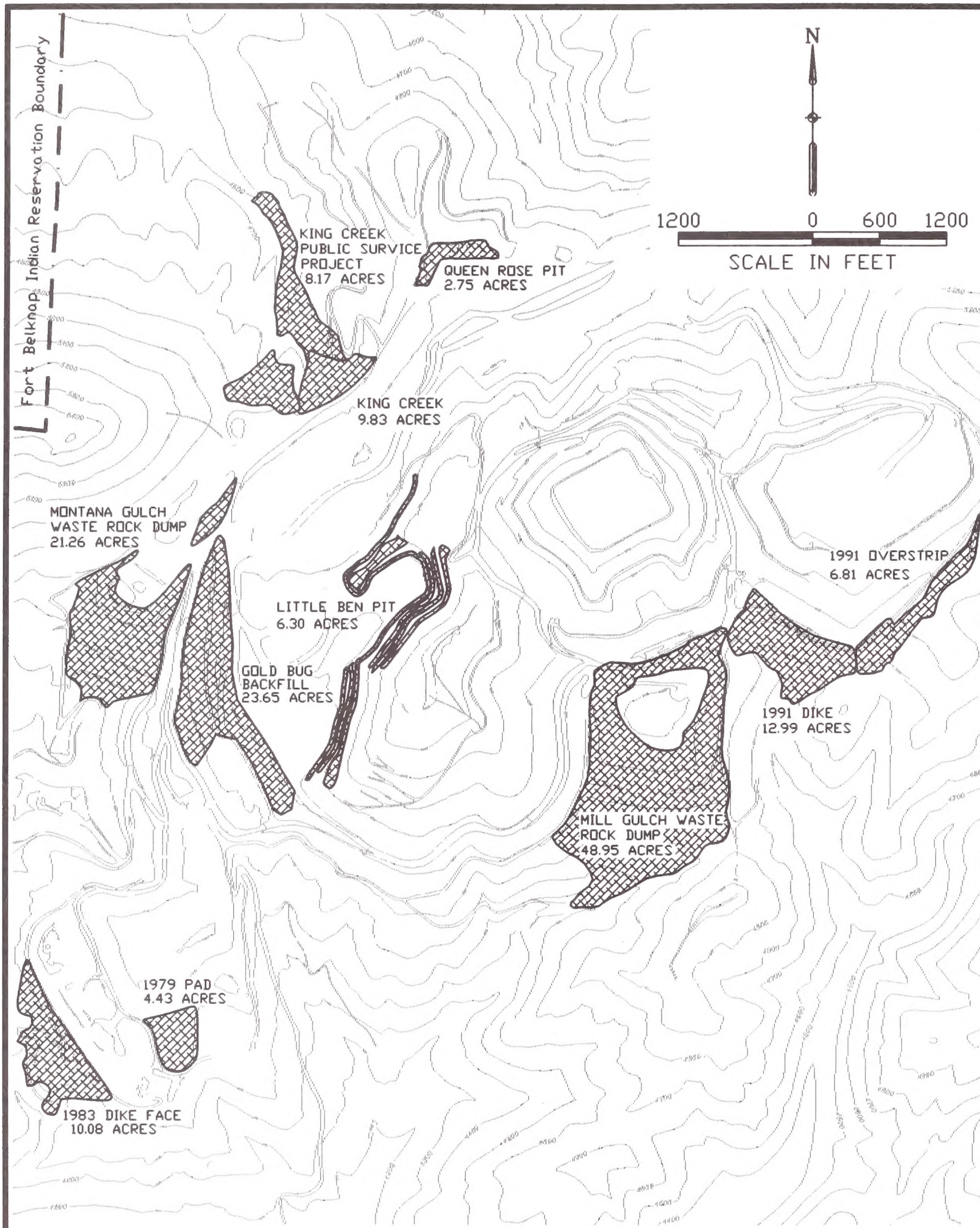
SOURCE: ZMI AMENDMENT TO OPERATING PERMIT 00096 DATED 4/5/93.

SCHEMATIC FLOW CHART DEPICTING SOLUTION TREATMENT AND HEAP DECOMMISIONING

FIG. 2.5-6

ZORTMAN MINE
EXISTING RECLAMATION

FIG. 2.5-7



SOURCE: ZORTMAN MINING INC., 9/94

LEGEND:

INDICATES AREA OF EXISTING RECLAMATION

LANDUSKY MINE
EXISTING RECLAMATION

173E0021

FIG. 2.5-8

hydroseeded, fertilized, and mulched in October, 1989. Tree and shrub seedlings were planted in April, 1990 using standard seedling planting techniques.

Zortman 80/81 Leach Pad - Fresh water flushing of the Zortman 80/81 leach pad was conducted during late summer and early fall of 1990. Rinse cyanide from the heap were reduced below 0.22 mg/l, verified by the sampling and reporting of October 12, 1990, and remained below the standard during February and March 1991 sampling events. However, leachate collected from the 79/80/81 pad complex shows elevated specific conductance (>8,000) and depressed pH (<4). These values indicate that ARD is accumulating in the spent ore site (ZMI 1994a). Surface reclamation of the heap included recontouring to a slope of 2H:1V, and application of approximately 8-inches of topsoil. Revegetation was achieved using hydroseeding, fertilizing and hydromulching. In 1992, nearly 12,000 trees and shrubs were planted.

Zortman 82 Leach Pad - The 82 leach pad is currently inactive and undergoing rinsing during precipitation events. Draining solution, mixed with natural precipitation, is piped to the Zortman process facility.

Zortman 83 and 84 Leach Pads - The 83 and 84 dike faces were resloped to 2H:1V, covered with a depth of 8 to 12 inches of topsoil and revegetated. Revegetation took place in August, 1992 using hydroseeding, fertilizing, and hydromulching. A pre-rinse was conducted during 1994 on the 84 pad using dilute fluids from within the pad as rinse water.

Zortman 85/86 Leach Pad - Rinsing of the 85/86 pad began during the 1992 operating season. Cyanide concentrations in the heap effluent have not yet been reduced to below the 0.22 mg/l standard. Topsoiling and revegetation activities have not yet been initiated on the heap. In December of 1992, approximately 200,000 tons of acid-producing material was removed from the buttress of this pad, and placed in the OK pit for storage. During this operation, 2.34 acres of reclamation cover were stripped from the dike face in the areas excavated.

Zortman 89 Leach Pad - The 89 pad is still under leach so surface reclamation has not been started. The dike face has been topsoiled and revegetated.

Landusky 79 Leach Pad - This pad has been reclaimed (rinsed, graded, topsoiled, and revegetated) using a minimum 8-inch topsoil cover.

Landusky 80/81/82, 83, and 84 pads - These pads are being rinsed.

Landusky 85/86, 87, 91 and the 87/91 pad - Ore leaching is occurring on these leach pads.

2.5.2.5 Waste Rock Facility Reclamation

In general, waste rock facilities would be reduced to a final overall slope of 2H:1V. Those facilities already reclaimed under the existing plan have been covered with 8 inches of topsoil and revegetated, as described in Section 2.5.2.8. At the Landusky Mine, this reclamation approach has been enhanced for operational waste rock disposal at the Mill Gulch and Gold Bug Butte waste rock repositories. Interim reclamation plans using a water barrier cover have been approved for these facilities with the provision that they may have to be undone, redone or modified pending outcome of this EIS.

Current reclamation, by facility, is described below and shown on Figure 2.5-7 and Figure 2.5-8. The disturbance area and reclamation status for each waste rock facility is shown on Table 2.5-7 and 2.5-8.

Zortman Mine

Alder Gulch Waste Rock Dump - In 1992, ZMI reclaimed this facility because of deterioration in water quality in seeps at the facility toe. The dump was regraded to 2.25H:1V slopes with one 25-foot bench at the mid-elevation. (Two other 25-foot benches have since been added to this facility.) The drainage bench was sloped to drain water off to either side of the repository. Topsoil was placed to a depth of 8 inches and the area was revegetated using a seed mix with an increased proportion of annual grasses to provide for an immediate dense reclamation cover and fertilized. During summer and autumn of 1993, another drainage bench was built at an elevation approximately 100 feet above the toe of the facility, and a pipeline was installed on the south side of the dump to carry runoff from the original drainage bench to the facility toe. There have been periodic failures of surface reclamation in this waste rock dump since 1993. Runon and runoff from large storm events have caused several incidents of rilling, gullying, and erosion of material from this dump into Carter Gulch. The most recent event occurred in July, 1995. Efforts are underway to ensure that runon water is directed away from the dump and to remove water from the dump surface.

OK Waste Rock Dump - The OK waste rock dump was resloped in 1992. Slopes were regraded to 2H:1V and topsoiled to a cover depth of 8 inches. Revegetation was initiated in spring of 1993.

Ruby Gulch Waste Rock Dump - The southern portion of the Ruby Gulch waste rock dump, commonly referred to as the "Sulfide Stockpile" was reclaimed in 1990. Prior to topsoil placement, the surface of the dump was amended with approximately 20,000 pounds of lime (CaO). Topsoil was spread to a depth of 8 inches. Revegetation was achieved in April 1990 by hydroseeding, fertilizing, and mulching.

Landusky Mine

Mill Gulch Waste Rock Dump

Seven acres of concurrent reclamation were removed during 1992. Reclamation Covers B and C have been placed over the facility to limit the supply of air and water to repository materials. Because of concern over infiltration through the flatter upper portion of the repository, particular attention was directed to developing a surface which reduced infiltration to near zero, both through regrading and through placement of a composite cap upon the facility.

Mill Gulch Waste Rock Dump, Upper Portion - The upper flat portion of the repository was resloped with a nominal 2 percent (1 percent - 4 percent actual) grade draining to the north. The principal barrier for this portion of the repository is a composite clay and synthetic liner system (Reclamation Cover C, see Section 2.5.2.2) covering the portion of the repository with slopes of less than 5 percent.

Clay and rock for the reclamation cover layers were end dumped from Caterpillar 777B and 777C haul trucks and spread with Caterpillar D9N and D10N bulldozers to the above specified thicknesses. The clay layer was compacted by movement of haul trucks, as well as roller compaction to an estimated greater than 95 percent density (visual inspection).

Mill Gulch Waste Rock Dump, Front Slope - The Mill Gulch waste rock dump has been resloped to a nominal 2.5H:1V to 3H:1V slope. This has been accomplished by reducing the upper portion of the repository to 2.75H:1V slopes, and the lower portions of the repository to 2.75H:1V to 3.5H:1V slopes. The resloped surfaces of the repository are completed with reclamation covers B or C, depending on the slope of the surface to be covered. Every 100 vertical feet, a 25-foot bench has been constructed to limit runoff velocities and allow for runoff to be moved to the lateral drain on the east side of the dump. The benches range from 15 to 30 feet wide and are sloped back into the repository with grades of 5 to 10 percent. These benches have been capped in a manner similar to the main portion of the repository.

Gold Bug Waste Rock Repository

During 1993, use of the Mill Gulch waste rock dump was discontinued. The Gold Bug pit was chosen for waste disposal because wastes would be stored outside of a natural drainage and the pit provides a convenient structure on which to construct a leachate collection system.

The objective for construction of this repository has been to limit the potential for acid generation. The base (3 feet deep across the 4,640 bench) of the repository was constructed with limestone and dolomite, and amended with 100 tons of lime distributed over the main Gold Bug Shear (see Section 3.1 for a geological explanation of shear zones). Blocks of material which are determined to be green waste (acid forming waste) are segregated within the repository interior. The margins of the repository are constructed with material which is determined to be yellow waste, containing 0.5 percent or less sulfur. The purpose of the waste segregation scheme is to line the perimeters of the repository with waste which should not cause acidic conditions and may provide some solution buffering capacity. Placement of the waste most likely to cause acid drainage within the interior of the repository will reduce the potential for acid leakage out of the pit. Reclamation Cover B typically is placed on waste rock as each lift is completed. Reclamation Cover C is used on slopes with less than 5 percent grade.

Montana Gulch Waste Rock Dump

Approximately 21 acres were disturbed in development of this dump, which contains about 8 million tons of waste rock. Reclamation took place in 1988 through 1990. About 8 inches of soil were placed on the disturbance. Approximately 36 pounds of seed were mixed per acre of disturbance, with approximately 100 pounds of fertilization per acre. Trees were planted on the reclaimed dump in September 1989 and April, 1990. Final dump slope was approximately 2H:1V.

2.5.2.6 Support Facilities Reclamation

Final reclamation of the mines includes the removal of all structures and equipment used in the mining and processing of ore. Structures and equipment to be removed include the:

- Processing plants, maintenance shops, and support service structures
- Refinery and carbon strip processing plant
- Leach pad pump and electrical structures
- Exposed process spray and return lines
- Electrical power lines, unless continued use is requested by private, public or regulatory agencies
- Property perimeter fencing
- Storage tanks and facilities

All cement structure footings and pads would be removed and used to help backfill depressions or openings such as ponds, or would be disposed appropriately as solid waste.

Final graded areas would be resoiled and revegetated to provide soil stability and reestablish vegetative communities. Other facilities would be reclaimed as follows.

Solution/Process Pond Reclamation

Ponds would be perforated, backfilled, and graded prior to final reclamation. Pond backfill would include fill material from waste rock operations and/or cement materials from structure footings or pads. After backfill, the ponds would be graded, covered with 8 inches of topsoil, and revegetated.

Sludges remaining in ponds at the end of mining operations would be sampled and analyzed to determine if there would be environmental hazards associated with on-site burial. If not, the sludge would be buried with spent ore or waste rock. If special handling of the sludge is required, cyanide in the sludge would be neutralized with an oxidizing agent and mixed into cement, with disposal in accordance with regulations of the Solid & Hazardous Waste Bureau. If sludge characteristics preclude in-place neutralization, another method of disposal would be used which meets federal and state requirements. This could include off-site disposal.

Soil Stockpile Reclamation

Topsoil stockpiles should be almost completely depleted by the time surface reclamation activities are finished. After all necessary cover soil is distributed to the disturbed areas, the stockpile locations would be revegetated.

Access and Haul Road Reclamation

Haul and access roadways would be reclaimed to establish suitable drainage. Roadways would be ripped to reduce surface compaction and provide additional fill material for grading of the surface. Roadway berms and loose, unconsolidated material above and below the roadway cut would be pulled or dozed into the roadway using a dozer or backhoe. Final graded areas would be topsoiled and revegetated.

Land Application Area

Significant disturbance of the land application areas is not anticipated since limited materials movement would be required. The Carter Butte, Goslin Flats (if permitted) and Gold Bug Butte LAD areas would likely not require reclamation measures. However, in the event of substantial vegetation loss due to the toxicity of applied solutions, the following activities would be undertaken to prevent soil erosion, minimize fire hazards, and return the loss to post-operation land use objectives:

- Cutting, stacking, and controlled burning of dead forest areas
- Placement of water bars or other devices to help control soil erosion
- Improve the soil to a condition suitable for revegetation using soil amendments and/or fertilizers
- Revegetation of the area

ZMI has committed to consult with the agencies in advance of any land application operation. Carter Butte has been used as a solution land application area in the past, but is probably no longer usable for this purpose (see Section 2.5.1.6). ZMI has proposed to use an area at Goslin Flats for land application. Whichever facility is used, ZMI has collected baseline soil analysis to evaluate the ability of soil in the proposed area to adsorb metals and cyanide. In addition, ZMI would perform annual soil analysis for a three-year period following land application to monitor for increases in metals and cyanide concentrations at the land application site.

Limestone Quarry Reclamation
Some disturbance has occurred at a quarry north of Shell Butte designated LS-1 (see Figure 2.5-2). A small amount of limestone was removed from this quarry for materials testing and drain construction. Reclamation of this area would include regrading, topsoil application and revegetation.

Seaford Clay Pit Reclamation
The Seaford Clay Pit, located approximately 7 miles south of Zortman (see Figure 2.5-2), has provided liner material for leach pad facilities at the Zortman Mine. This clay pit has been reclaimed in accordance with the permit requirements established by the DSL Open Cut Bureau.

Williams Clay Pit Reclamation
The Williams clay pit approximately 2 miles west of Landusky has provided liner material for leach pad facilities and cover layer for reclamation caps. This clay pit would be reclaimed in accordance with the permit requirements established by the DSL Open Cut Bureau.

2.5.2.7 Reclamation Quality Control

No procedures are specified in the current permit for documenting quality control of reclamation practices such as cover soil thickness, seeding rates, drainage construction, etc. Quality control reports have been submitted for installation of the compacted clay used in covers on the Mill Gulch and Gold Bug waste rock repositories.

2.5.2.8 Revegetation Procedures

Areas disturbed at the mines are revegetated to stabilize soil and slopes, reestablish communities ecologically comparable to pre-mine conditions, and restore watershed, wildlife, recreational and aesthetic values that meet post-operation land use objectives. The following sections described ZMI's reclamation revegetation program.

Species Selection
Plant species selected for revegetation are based on species occurrence within the project area, land use objectives, presence of the species on pre-mine disturbances, establishment potential, growth characteristics, soil adaptation and stabilizing qualities, wildlife palatability, and commercial availability.

Plant species are obtained from dealers within Montana. ZMI has used various mixtures of species during reclamation activities at the mine. These species have varied primarily due to availability and application; for instance, a different species mix may be used on heap leach pad dike faces as opposed to the top surfaces of pads. In addition, post-revegetation monitoring by independent consultants is conducted to evaluate reclamation success and suggest species modifications, where needed. As new species are released for distribution, they are considered for inclusion in the revegetation program.

Seedbed Preparation
Seedbeds are prepared immediately after grading, topsoil cover placement, and fertilizer application. On slopes of 33 percent or less, the seedbed is disced and harrowed along contour to break up large clods. On slopes exceeding 33 percent, sites too narrow to negotiate equipment, or on sites where organic debris has been respread, the soil surface is left in a roughened condition. Seed and mulch are applied to fresh road cuts and fills in areas subject to erosion as soon after construction as possible.

ZMI uses surface ripping techniques, fertilization, and mulching to enhance revegetation success potential. Ripping is conducted on soil stockpile sites, road surfaces, and other areas where compaction has occurred. Compacted soil on level areas are tilled to break up the soil mass and improve water and air movement through the subsurface.

Seeding Methods
Seeding is coordinated with other reclamation activities to occur as soon after seedbed preparation as possible. Fall seeding is preferred, based on local soil moisture conditions, germination requirements of selected species, and timing of construction activities. Spring seeding is practiced if areas are ready for revegetation and access is possible.

Both broadcast and drill seeding methods are used, although the majority of disturbances are broadcast seeded. Broadcast seeding is used on rocky areas, slopes steeper than 3H:1V, areas where organic debris has been respread, and small disturbances. Seed is broadcast using manually operated cyclone-type bucket spreaders, a mechanical seed blower, or a hydroseeder. Where possible, broadcast seed areas are chained or harrowed to cover the seed. Where slope conditions allow, seeded areas would be dozer-tracked perpendicular to the slope. Seed would be covered by hand raking on smaller, less accessible sites.

Drill seeding would be done along contour wherever the reclamation surface is not level to achieve proper seed placement depth and promote good contact between seed and soil. Drill row spacing would range from 7 to 14 inches. Drill seeding would not be used in areas where reclaimed surface have rocky soil or where organic debris has been re-spread.

Fertilizer mixes and application rates are based on soil tests; rates are formulated to achieve soil macronutrient levels capable of promoting plant growth and productivity. Seed, fertilizer, and mulch typically would be sprayed in one application of about 250 lbs/acre when hydroseeding. When used, mulch is spread evenly over seeded areas at rates dependent on seeding method and slope. Mulch is anchored into the seedbed using a mulch crimper, disc, or tracked dozer. A tackifier is applied on areas that are mulched in the fall and on areas which require prompt stabilization. Where hydromulching is used, a second mulch application accompanied with a tackifier binding would be sprayed along the disturbance at manufacturer's recommended application rates.

Planting Methods

Tree species are planted continuously across slopes such as dike faces, sloped areas of leach pads, and waste dumps, and in clumps along level areas such as plant sites, and the tops of leach pads and waste repositories. Heap leach pads and waste dump tops are planted in islands on level areas, with 10 to 30 percent of the area planted in forest species and the remainder planted in grasses for wildlife grazing. Distribution of the various tree species depends on slope, reclamation surface, and moisture conditions.

ZMI initially plants 400 trees per acre. Based on an anticipated survival rate of 65 percent, the final stocking rate after 15 years would be about 260 trees per acre. The appropriate planting time is determined by site conditions such as soil moisture, soil temperature, air temperature, site accessibility, and previous reclamation planting experiences with trees and shrubs at Zortman Mine disturbances. Tree stock is delivered to the site as close to the time of planting as possible, with no stock handled when the air temperature is below freezing and no planting when frost is still in the soil. Hand tools and power-driven augers or similar machines are used to plant trees and shrubs. Mulching may be employed to conserve moisture and reduce competition.

If available, stock inoculated with mycorrhiza is planted to enhance growth and prospects for plant survival. Partial shade from logging debris, snags, or other sources is used to help establish seedlings. If tree seedling survival is less than 65 percent three years after planting, supplemental planting is considered.

Interim Revegetation

To reduce erosion and sedimentation during the life of the operation, some disturbances such as soil stockpiles are vegetatively stabilized prior to final reclamation. Topsoil is not applied to those areas which are temporarily revegetated. These sites are broadcast seeded or hydroseeded. Mulch and fertilizer are added. Interim revegetation takes place during the first appropriate season after construction is completed.

2.5.3 Monitoring Programs and Research Studies

2.5.3.1 Water Resources

Surface and groundwater monitoring programs at the Zortman and Landusky mines consist of quarterly water resources monitoring, with data analyzed by an outside laboratory, and more frequent operations monitoring, performed by ZMI employees. The primary objective of the monitoring programs is to detect any leakage from the process circuit or seepage from mine waste facilities.

The current water resources monitoring program consists of quarterly monitoring of 57 surface water and 58 groundwater stations around the Zortman and Landusky mines. Operational water monitoring is also conducted at selected surface water and groundwater monitoring sites in the mining and ore processing areas by mine personnel on a daily, weekly, or monthly basis, depending on the site. Exhibits 1 and 2 show the water resources monitoring locations for the Zortman and Landusky mines, respectively.

Water Resources Monitoring

A summary of groundwater stations for Zortman and Landusky is presented in Tables 2.5-13 and 2.5-14. In 1995 the Zortman area groundwater monitoring sites included 30 monitoring wells, a community supply well (Z-8A) and an industrial water supply well (ZL-163). 1995 Landusky sites consisted of 33 groundwater monitoring stations including 29 monitoring wells, and 4 private wells.

Surface water monitoring includes spring and fall collection of water quality samples and measurements or estimates of flow for streams, springs and seeps. A total of 57 stations (30 Zortman sites, 27 Landusky sites) were included in the water resources monitoring program during 1995. Tables 2.5-15 and 2.5-16 provide a summary of surface water stations for the Zortman and Landusky areas.

TABLE 2.5-13
ZORTMAN GROUNDWATER MONITORING SITES[1]

Site	Site Description	Site	Site Description
AG-200	Alder Gulch above confluence with Tributary	ZL-145	Ruby Creek
AG-201	Alder Gulch above confluence with Tributary	ZL-146	Ruby Creek
AG-202	Alder Gulch below Pony Gulch	ZL-147	Goslin Gulch
AG-203	Alder Gulch Bedrock Well	ZL-148	Lower Goslin Gulch
RG-99	Ruby Gulch above Process Pond Area	ZL-149	Lower Goslin Gulch
RG-110	Ruby Gulch Alluvium	ZL-150	Lower Goslin Gulch
RG-111	Ruby Gulch Bedrock	ZL-151	Upper Goslin Gulch
ZL-8A	Zortman Services Water Assoc.	ZL-152	Upper Goslin Gulch
ZL-102	300 feet east of ponds	ZL-153	Goslin/Ruby Creek
ZL-110	Tributary of Alder Gulch	ZL-154	Goslin Gulch on terrace
ZL-134	Below 1989 Leach Pad	ZL-163	Zortman Mine supply
ZL-135	Shallow well below 1989 Leach Pad	ZL-200	Ruby Ross Pit Well
ZL-142	Lower Ruby gulch Monitoring Well above Zortman	ZL-201	Mint Pit Well
ZL-143	Lower Ruby Gulch Monitoring Well above Zortman	ZL-202	OK Pit Well
ZL-144	Lower Ruby Gulch Monitoring Well above Zortman	ZL-207	OK Pit Well
		ZL-209	Glory Hole Gulch
		ZL-210	Glory Hole Gulch

[1] Exhibit 1 shows the groundwater monitoring sites around the Zortman Mine.

TABLE 2.5-14
LANDUSKY GROUNDWATER MONITORING SITES[1]

Site	Site Description	Site	Site Description
ZL-105	Tributary to Mill Gulch	ZL-136	Lower Mill Gulch Monitoring Well
ZL-108	60 ft south of Barren Pond	ZL-137	Lower Mill Gulch Monitoring Well
ZL-109	Tributary to Mill Gulch	ZL-138	Lower Mill Gulch Monitoring Well
ZL-112A	Replacement for ZL-112	ZL-139	King Creek
ZL-113	Tributary to Montana Gulch	ZL-155	Mill Gulch below Containment
ZL-114R	Tributary to Montana Gulch	ZL-156	Mill Gulch below Containment
ZL-115	Tributary to Montana Gulch	ZL-157	Mill Gulch below Containment
ZL-116	Tributary to Montana Gulch	ZL-158	Landusky Yard Well
ZL-118	20 ft NW of Barren Pond	ZL-159	Landusky Yard Well
ZL-119	Montana Gulch downstream 1985 Leach Pad Dike	ZL-160	Landusky Yard Well
		ZL-161	Landusky Yard Well
ZL-123	Montana Gulch below Containment pond south of dike	ZL-162	Montana Gulch, below pond
ZL-124	Montana Gulch below Containment pond south of dike	ZL-164	Sullivan Park, below lower containment pond
ZL-125	Montana Gulch below Containment pond south of dike	ZL-165	Sullivan Park, below lower containment pond
ZL-131	Rock Creek below Containment Pond	TP-1	Mobile Home Well
		TP-2	Landusky Private Well
ZL-132	Rock Creek below Containment Pond	TP-3	Domestic Water Supply
ZL-133	Lower Rock Creek	TP-4	Landusky Private Well

[1] Exhibit 2 shows the groundwater monitoring sites around the Landusky Mine.

TABLE 2.5-15
ZORTMAN SURFACE WATER MONITORING SITES[1]

Site	Site Description	Site	Site Description
Z-1	Ruby Gulch below historic mill site	Z-20	Goslin Gulch Tributary
Z-1B	Ruby Gulch above town of Zortman	Z-21	Goslin Gulch Spring
Z-2	Alder Gulch below Carter confluence	Z-22	Lower Goslin Gulch
Z-3A	Alder Gulch above Tributary	Z-27	Tributary to Beaver Creek
Z-5	Glory Hole Creek at Mouth	Z-28	Tributary to Lodgepole Creek
Z-6	Spring in upper Lodgepole Creek	Z-29	Lodgepole Creek
Z-6A	Tributary above Alder Gulch	Z-30	Upper Lodgepole Creek
Z-7	Lodge Pole Cr. above Reservation	Z-31	Beaver Creek below Tributary
Z-8	Alder Gulch at former Kalal water supply intake	Z-32	Ruby Creek above Goslin
Z-13	Tributary to Alder Gulch	Z-33	Spring on Lower Ruby Creek
Z-14	Tributary to Alder Gulch	Z-34	Spring on Ruby Creek Tributary
Z-15	Ruby Gulch at Permit Boundary	Z-35	Dev. Spring on Goslin Gulch
Z-16	Alder Gulch	Z-36	Section-32 Cistern
Z-17	Ruby Creek below Zortman	Z-37	Pumpback System below Dike
Z-18	Ruby Creek Tributary	Z-42	Lower Carter Gulch
Z-19	Goslin Gulch	Z-45	Tributary to Carter Gulch

[1] Exhibit 1 shows the surface water monitoring sites around the Zortman Mine.

TABLE 2.5-16
LANDUSKY SURFACE WATER MONITORING SITES[1]

Site	Site Description	Site	Site Description
L-1	Rock Creek at Kolczak Road	L-20	Seep above Tributary to South Big Horn Creek
L-2	Montana Gulch at County Road	L-21	Tributary to South Big Horn Creek
L-3	Gold Bug Adit Discharge	L-22	Spring in Mill Gulch above town of Landusky
L-4	Rock Creek at town of Landusky	L-23	Rock Creek above Landusky
L-5	King Creek Spring	L-27	Sullivan Park below Contingency Pond
L-6	King Creek at Upper Beaver Ponds	L-28	Upper Rock Creek Leach Pad Underdrain
L-7	Mill Gulch at Mouth	L-29	Tributary to Upper Rock Creek
L-8	Spring flow below Process Ponds	L-31	Gold Bug Pipeline Road at Culvert
L-9	Tributary to Mill Gulch	L-32	Gold Bug Pipeline Road at Culvert
L-11	Tributary to Montana Gulch	L-35	Mill Gulch above Contingency Pond
L-12	Tributary to Montana Gulch	L-36	Mill Gulch below Contingency Pond
L-13	Tributary to Montana Gulch	L-37	Sullivan Park
L-14	Tributary to Montana Gulch	L-38	South Montana Gulch Waste Dump
L-16	Montana Gulch below Leach Pad Dike	L-39	Upper King Creek near Reservation Boundary
L-17	Leach Pad Underdrain		
L-19	Tributary to South Big Horn		

[1] Exhibit 2 shows the surface water monitoring sites around the Landusky Mine.

Samples are collected by an outside consultant in the spring and fall, while ZMI collects winter and summer samples. All spring samples are analyzed for major cations and anions, metals, cyanide, and physical parameters ("complete" analysis). Either complete, or an abbreviated "indicator" analysis are conducted during summer, fall, and winter events. Monitoring wells along permit boundaries and below major facilities are analyzed for the complete list during all sampling events. Analyses for the "complete" tests are conducted by an outside laboratory. The quarterly data reports and an annual Water Resources Monitoring Report which include a description of sites monitored and their monitoring frequency, and chemical analyses conducted for all samples, are submitted each year to regulatory agencies. Tables 2.5-17 and 2.5-18 present the indicator and complete parameter list, analytical methods and detection levels for surface water and groundwater samples at the Zortman and Landusky mines.

Operations Monitoring

Operations water resources monitoring is also conducted in the mining and ore processing areas by mine personnel on a daily, weekly or monthly basis at selected surface water and groundwater monitoring sites. Samples are analyzed for select field parameters such as pH and temperature. Depending on the sample location and data need, other analytes from the indicator sampling program (Table 2.5-17) may be assessed as well. Operational monitoring data summaries are submitted monthly to the BLM and DEQ by ZMI.

2.5.3.2 Reclamation Surface Performance Study

The Reclamation Surface Performance Study (RSPS) was initiated in 1993 to evaluate measures intended to improve reclamation success for the Mill Gulch waste rock dump and other facilities at the Landusky and Zortman mines. This study consists of four stages:

- Stage 1: Help Model Evaluation
- Stage 2: Preliminary Field Trials
- Stage 3: Comprehensive Field Trial
- Stage 4: Operational Monitoring

The first two stages have been implemented. Stages 3 and 4 are planned for implementation, but it is likely ZMI would not carry forward these research programs if the agencies do not approve mine expansions.

Stage 1: Help Model Evaluation

The initial stage of the program was development of repository water budgets for each of the infiltration trial surfaces using the Hydraulic Evaluation of Landfill Performance (HELP) model. Meteorological data from the Landusky meteorology station was used for model runs. Size distribution data for repository materials was obtained from completed studies on leach pad decommissioning, Zortman Mine Extension studies, and field examination. All model runs used the assumption that a synthetic liner/clay cap cover would be placed over the upper portions of the repository. Results from the HELP modeling indicated that the similarity of performance of the 3-inch, 6-inch, and 12-inch caps in compacted clay simulations suggests that quality control issues in clay liner installation would likely be more important than designed cap thickness.

Additional HELP modeling was conducted for the slope capping scenario consisting of 12 inches of compacted clay, a 36-inch capillary break, and 8 to 12 inches of cover soil. Hydraulic conductivity values for the compacted clay layer of $1x10^{-5}$, $1x10^{-6}$, and $8.5x10^{-7}$ cm/s were used in this comparative evaluation.

Stage 2: Preliminary Field Trials

Short-term field trial test plots are being reconstructed to test trial covers 926, 927, 928, and 929, as shown on Table 2.5-19. These trial covers include the systems which have been installed on the Mill Gulch waste rock repository (Trial 926 and 929), as well as other similar systems.

Stage 3: Comprehensive Field Trial

Stage 3 of the RSPS involves evaluating long-term field trials of reclamation covers by in situ monitoring. Stage 3 will evaluate the two reclamation covers (926 and 929) constructed on the surface of the Mill Gulch waste repository during 1994. Cover 926 was constructed on the 40 acres of repository slopes, and cover 929 was constructed on the 10 acres of the repository top. (Note: As of March 1996, construction of the reclamation cover is approximately 95 percent complete, with the remainder scheduled for completion during 1996. To evaluate these covers on a field scale, three monitoring sites have been installed. Site 1 is located on the repository top (cover 929). Sites 2 and 3 are located on the repository slope (cover 926). Site 2 is located on a mid-slope bench, and Site 3 is located on a bench near the toe of the repository. Each monitoring site is instrumented with neutron probe access tubes to monitor volumetric water content and flux; a pore gas

TABLE 2.5-17

INDICATOR ANALYTES FOR WATER RESOURCES MONITORING

Constituent	Analytical Method	Routine Detection Limit
pH	EPA 150.1	0.1 s.u.
Specific Conductance	EPA 120.1	1 umhos/cm
Total Dissolved Solids	EPA 160.1	1 mg/l
Total Hardness ($CaCO_3$)	EPA 200.7	1 mg/l
Alkalinity ($CaCO_3$)	EPA 310.1	1 mg/l
Total Cyanide	EPA 335.3	0.005 mg/l

TABLE 2.5-18
ANALYTES FOR WATER RESOURCES MONITORING[1] - COMPLETE ANALYSIS

Constituent	Analytical Method	Routine Detection Limit
Total Suspended Solids (TSS)	EPA 160.2	1 mg/L
Total Dissolved Solids (TDS)	EPA 160.1	1 mg/L
Turbidity (NTU)	EPA 180.1	0.01 NTU
Specific Conductance (SC)	EPA 120.1	1 μmhos/cm
pH	EPA 150.1	0.1 s.u.
Flow (surface water)	N/A	N/A
Depth to water (wells)	N/A	N/A
Calcium (Ca)	EPA 215.1/200.7	1 mg/L
Magnesium (Mg)	EPA 242.1/200.7	1 mg/L
Sodium (Na)	EPA 273.1/200.7	1 mg/L
Potassium (K)	EPA 258.1/200.7	1 mg/L
Bicarbonate (HCO3)	EPA 310.1	1 mg/L
Carbonate (CO3)	EPA 310.1	1 mg/L
Chloride (Cl)	EPA 300.0	1 mg/L
Sulfate (SO4)	EPA 300.0	1 mg/L
Nitrate + Nitrite as N	EPA 353.2	0.05 mg/L
Total Hardness as CaCO3	EPA 200.7	1 mg/L
Total Alkalinity as CaCO3	EPA 310.1	1 mg/L
Acidity as CaCO3 (if pH < 6.0)	EPA 305.1	1 mg/L
Ammonia	EPA 350.1	0.1 mg/L
Total Cyanide (CN)	EPA 335.3	0.005 mg/L
Cyanide - Weak Acid Dissociable Cyanide (WAD)	ASTM D2036	0.005 mg/L
Free Cyanide	Electrode	0.2 mg/L
Aluminum (Al)	EPA 202.1/200.7	0.1 mg/L
Arsenic (As)	EPA 206.2	0.005 mg/L
Cadmium (Cd)	EPA 213.1/200.7	0.001 mg/L
Copper (Cu)	EPA 220.1/200.7	0.01 mg/L
Chromium (Cr)	EPA 218.1/200.7	0.01 mg/L
Iron (Fe)	EPA 236.1/200.7	0.03 mg/L
Manganese (Mn)	EPA 243.1/200.7	0.01 mg/L
Lead (Pb)	EPA 239.2/200.7	0.01 mg/L
Mercury (Hg)	EPA 245.2	0.001 mg/L
Nickel (Ni)	EPA 249.1/200.7	0.01 mg/L
Selenium (Se)	EPA 270.3	0.005 mg/L
Silver (Ag)	EPA 272.2/200.7	0.005 mg/L
Zinc (Zn)	EPA 289.1/200.7	0.01 mg/L

[1] Flow, total suspended solids (TSS) and turbidity omitted for groundwater. All metals analyzed as dissolved in groundwater; as total recoverable in surface water. If total cyanide is not above detection limit then WAD cyanide and free cyanide are not tested.

TABLE 2.5-19
SHORT-TERM RECLAMATION TRIAL COVERS

Trial Cover	Substrate	Barrier	Capillary Break	Top Cover
Trial 926	yellow waste	12 inches clay	36 inches blue waste	12 inches coversoil
Trial 927	yellow waste	12 inches soil	36 inches blue waste	12 inches coversoil
Trial 928	yellow waste	6 in. lime/ limestone	36 inches blue waste	12 inches coversoil
Trial 929	yellow waste	3 in. clay/ 20 mil PVC liner	36 inches blue waste	12 inches coversoil

sampler to monitor internal oxygen content; suction lysimeters to monitor pore water quality at various depths; and a monitoring well completed at the base of the rock fill to monitor water quality and quantity. Initial and long-term monitoring of these parameters will enable an evaluation of the effectiveness of the reclamation covers in reducing infiltration.

The Reclamation Research Unit at Montana State University was contracted to provide oversight for this project. Their primary tasks include: 1) provide field oversight and assistance during installation of monitoring equipment (task completed); conduct a detailed field calibration of neutron probe data (scheduled for Spring 1996); assist in data collection from monitoring sites (on-going); and prepare a research report with data interpretations for the initial two year monitoring period.

Stage 4: Operational Monitoring

Stage 4 involves operational monitoring of overall effectiveness of reclamation on the Mill Gulch waste repository. Routine monitoring will be conducted at instrumented sites over the long-term to assess conditions and changes in water content, internal temperatures and pore gas chemistry. These parameters will be used to evaluate the overall efficiency of the cover system in limiting infiltration and associated oxidation reactions. The major focus of Stage 4 will be identification of long-term trends in these key parameters.

Evaluations will also be conducted on vegetation and storm water control performance. Vegetative performance will be evaluated biannually by measurement of canopy coverage. Storm water control and associated erosion will be evaluated by visual inspection.

2.5.3.3 Surface Reclamation Monitoring

ZMI uses an independent consultant to monitor revegetation success. The consultant periodically checks vegetation in reclaimed areas to determine if revegetation species have taken hold at the desired density and sustainable viability. Reclamation success is qualitatively evaluated with results included in the annual Operating Report submitted to the agencies. Vegetation monitoring studies including test plot studies were conducted in 1988, 1989, 1990, and 1992. ZMI intends to initiate biannual vegetation monitoring that would focus on canopy coverage.

2.5.3.4 Air Quality Monitoring

Air quality monitoring and meteorologic data collection for the Zortman and Landusky mining area was initiated in March, 1990. ZMI has used the services of a consulting meteorologist for this program.

Ten stations have been established. The station number, elevation, location and a list of parameters monitored are presented in Table 2.5-20. ZMI temporarily decommissioned sites 7, 8, 9, and 10, which were installed to gather baseline data for the extension project, at the end of 1994.

PM-10 sampling is conducted on a winter and summer schedule. Winter samples (November through April) are collected weekly and summer samples (May through October) are collected twice per week. Sites with weather stations (3, 4; when operating also 7, 8, 9, and 10) contain continuous recorders for listed parameters and are downloaded monthly using an electronic data logger. Annual air quality monitoring reports are required to be submitted to the DEQ and BLM.

2.5.3.5 Wildlife Monitoring

Wildlife mortality monitoring is conducted at both the Zortman and Landusky mines. The report does not include mortality information on insects, rodents, or reptiles. Mine personnel conduct weekly inspections of process pond nets and monthly random inspections of minesite and boundary fences. A monthly report for each mine site is submitted to the DEQ and the BLM. These reports contain information on wildlife mortality (if any) during that month, including species identification, number, location, suspected cause of death, and future preventative actions.

2.5.4 Reasonably Foreseeable Future Actions

2.5.4.1 Mine Activities

While there would be no mine expansion or enhanced reclamation activities, it is reasonable to anticipate future requests for actions needed to improve ARD capture and treatment. Since this alternative does not emphasize ARD source control, construction of permanent ARD capture and treatment facilities are foreseeable.

TABLE 2.5-20
AIR QUALITY AND METEOROLOGICAL MONITORING SITES

Site	Elevation	Location	Parameters Monitored
1	3837	Kolczak Ranch, southwest of Landusky Mine	PM-10 suspended particulates
2	4000	town of Landusky	PM-10 suspended particulates
3	5160	downwind of the Landusky Mine at Gold Bug Butte	Wind Speed, Wind Direction, Wind Sigma, Temperature, Relative Humidity, PM-10 suspended particulates (2), Precipitation
4	5084	Zortman Mine boneyard, west of 84 pad	Wind Speed, Wind Direction, Wind Sigma, Temperature, Relative Humidity
5	4000	town of Zortman	PM-10 suspended particulates
6	4000	downwind of the Zortman Mine southeast of the Zortman school	PM-10 suspended particulates
7	3680	7-mile station, east of the main road to Zortman (decommissioned, 12/94)	Wind Speed, Wind Direction, Wind Sigma, Temperature, Relative Humidity, PM-10 suspended particulates, Precipitation
8	3640	east of Zortman in Beaver Creek (decommissioned, 12/94)	Wind Speed, Wind Direction, Wind Sigma, Temperature, Relative Humidity, PM-10 suspended particulates
9	3400	Lodge Pole (decommissioned, 12/94)	Wind Speed, Wind Direction, Wind Sigma, Temperature, PM-10 suspended particulates
10	3560	Hayes (decommissioned, 12/94)	Wind Speed, Wind Direction, Wind Sigma, Temperature, Relative Humidity, PM-10 suspended particulates

2.5.4.2 Mine Support Facilities

A permanent facility for storage or disposal of sludges produced by the water treatment plants is foreseeable. No major upgrades to access roads or electrical power service are foreseeable.

2.5.4.3 Exploration Activities

While this alternative does not preclude future proposals for exploration activities, none are anticipated. Since this alternative would not provide for the mining of already delineated ore reserves, the incentive to explore for additional reserves would be very low.

2.6 ALTERNATIVE 2: MINE EXPANSIONS NOT APPROVED AND COMPANY PROPOSED RECLAMATION

This alternative would not approve additional mining at the Zortman and Landusky mines, but allows those mine activities already permitted, such as ore leaching and rinsing to continue. The difference from the No Action Alternative is that this alternative includes ZMI's modifications to the currently approved reclamation procedures at the two mines. Chapter 4.0 of this Final EIS presents an evaluation of the environmental impacts projected to occur using the revised reclamation procedures proposed by ZMI for the two mines.

Field inspections of both mines, and reviews of water quality monitoring, provided data that ZMI's existing operating and reclamation plans were not providing sufficient environmental protection. In response to agency directives, this alternative was proposed by ZMI in recognition that many of the reclamation procedures which have been used at the Zortman and Landusky mines have not adequately protected environmental resources, particularly groundwater and surface water systems. ZMI submitted a plan in January, 1994, which contained the revised reclamation procedures presented in this alternative (ZMI 1994a). ZMI has proposed the same revised reclamation procedures for the Landusky Mine as are described for the Zortman Mine.

The reclamation cover materials used for this alternative would be limited to soil and clay. Little, if any, limestone and/or non-acid generating waste rock would be used in reclamation covers, except on select Landusky Mine facilities.

This alternative is presented in six sections:

- Section 2.6.1 describes the mine operations at the Zortman and Landusky mines. However, since mining under this alternative would not differ from the mining presented in Alternative 1 (Section 2.5.1), the description is limited to a summary of permitted mining operations.
- Section 2.6.2 describes the reclamation activities required under this alternative for the Zortman and Landusky mines, with emphasis on those reclamation procedures which are modified from the currently permitted procedures.
- Section 2.6.3 describes the monitoring programs in place at the two mines.
- Section 2.6.4 presents an evaluation of future activities which have a reasonably foreseeable opportunity of occurrence under this alternative.

For reference, Figure 2.5-1 and Exhibits 1 and 2 show the current permit boundaries and facilities for both mines.

2.6.1 Mine Expansions Not Approved

This alternative would not approve plans for further mining at either the Zortman or Landusky mines beyond that already authorized under the existing permits. Alternative 1 provides a complete description of the currently permitted mining activities, which are summarized below.

No ore has been mined at the Zortman Mine since 1990. Ore which has already been loaded would continue to be leached to extract gold and silver from the rock matrix. The leaching solution would be stored in the pregnant solution holding pond until it is run through the process plant to remove the metals from solution. Spent or barren solution would continue to be recycled for later use in ore heap leaching. Rinsing of the existing leach pads would continue until cyanide concentrations in monitoring locations fall below 0.22 WAD cyanide for a six month period. Final drain-down solution would be piped to the Landusky Mine for use as makeup water or disposed at the Goslin Flats land application area.

Permitted mining operations are nearing completion at the Landusky Mine. Ore-bearing rock is blasted from the Queen Rose, Little Ben, and South Gold Bug pits and loaded on to the 87/91 heap leach pad for processing. Waste rock generated from the pit is being deposited into the Gold Bug and Queen Rose waste rock repositories in accordance with the waste characterization and handling plan described in Section 2.5.1.1. Ore is loaded onto the 87/91 pad and a cyanide solution is used to extract gold and silver from the rock

matrix. The pregnant solution is collected from the bottom of the heap and pumped to a solution storage pond. From there the pregnant solution is processed using Merrill-Crowe or carbon adsorption methods to remove dissolved metals from the solution. The gold and silver is collected, refined into dore, and shipped from the mine to another refinery for further processing. The spent cyanide solution is pumped to a barren pond to be reused in the ore leaching circuit.

Ore leaching is still occurring on the 85/86, 87, 91, and 87/91 leach pads, but the only pads still being loaded are the 91 and 87/91. The 80/81/82, 83, and 84 pads are still being rinsed and will continue until cyanide concentrations in monitoring locations fall below 0.22 WAD cyanide for a six month period. Final draindown solution is to be disposed at the land application area on Gold Bug Butte or transferred to the Zortman Mine via pipeline and disposed at the Goslin Flats LAD area.

2.6.1.1 Water Management

Alternative 1, Section 2.5.1.6, presents an overview of water management plans prepared by ZMI to mitigate water quality impacts from mine facility discharges. It includes a description of measures that have been or would be implemented for management of process waters, storm waters and mine drainage. The few changes from Alternative 1 incorporated into this alternative are described below. Additional detail on measures to improve and maintain water quality are contained in the Water Quality Improvement Plan which is presented in Appendix A.

Objective: The objective under all alternatives is to protect beneficial use and to achieve and maintain compliance with water quality standards.

Approach: This alternative places moderate reliance upon capture and treatment of impacted waters. By improving surface reclamation and runon diversions, ZMI would attempt to limit infiltration of precipitation into mine waste that may generate undesirable effluent. Still, long-term capture and treatment of impacted waters are anticipated to be necessary to meet the water management objective.

Surface Water Runoff Control

The location of runoff control structures would remain as described in Alternative 1. Alternative 2 requires that all surface water diversions be sized to convey runoff from a 100-year, 24-hour storm event at mine closure. This would require upgrading some of the existing operational drainage structures designed for flows from the 10-year, 24-hour storm event.

Water Capture

The location of water capture structures would remain as described in Alternative 1. Alternative 2 requires that structures be sized to capture seepage resulting from a 10-year, 24-hour storm event as a minimum. Additional information concerning the capture systems is found in the Water Quality Improvement Plan, Appendix A.

Water Treatment

The location and function of the water treatment plants would remain as described in Alternative 1 and Appendix A. ZMI constructed a 2,000-gpm water treatment plant in May 1994 to treat seepage water captured at the toe of existing mine waste rock dumps at the Zortman Mine. The plant operates at a rate of 200 to 2,000 gpm depending on factors such as precipitation amounts and seasonal operating conditions. Another water treatment plant is planned for the Landusky Mine and would be located in the Montana Gulch area. Interim effluent discharge standards from the plant are BAT for mine waters (40 CFR §440.100). Establishment of final effluent limits and outfall points would occur as part of MPDES permit development.

The water treatment plants would continue to operate until final reclamation measures have successfully produced effluent that meets the water quality standards. Under Alternative 2, even with the proposed placement of enhanced reclamation covers, long-term operation of water treatment plants would most likely be necessary at both mines to meet water quality objectives for some of the affected drainages.

Land Application Disposal

The location and operation of the land application areas would not change from Alternative 1. Provisions for land application disposal are required by the regulatory agencies for final heap draindown at mine closure, or in the case of an extreme precipitation event that overwhelms the capacity of the leaching circuit. In the land application process leaching solutions are treated with either hypochlorite or hydrogen peroxide to detoxify the cyanide. All solutions must be at or below 0.22 mg/l WAD cyanide prior to land application. Use of land application as a water management practice requires advanced notification and review by the regulatory agencies prior to each land application event to verify the character of the applied solutions, remaining soil attenuation capacity, and necessary monitoring techniques.

2.6.2 Company Proposed Reclamation

The reclamation procedures for the Zortman Mine were proposed by ZMI in January, 1994, in response to requirements by the agencies to modify the reclamation plans for the Zortman Mine to address the existing ARD data (ZMI 1994a). The reclamation procedures for the Landusky Mine were proposed by ZMI in late 1994, and updated in March of 1995 in response to requirements of the agencies to modify reclamation plans to address existing ARD problem

The primary objective of the modifications to reclamation procedures proposed by ZMI is to mitigate environmental problems at the mine without relying on additional ore or waste rock mining.

Approval of final reclamation plans for the mines have been deferred pending completion of this Final EIS (DSL/BLM 1994a). In the interim, ZMI has undertaken some actions to correct environmental problems at the Landusky Mine. Composite, RCRA-type covers have been placed on the Mill Gulch waste rock dump and Gold Bug waste rock repository. Modifications have been made to upgrade surface water capture systems. This alternative describes those additional actions that ZMI would undertake to enhance the potential for reclamation success.

2.6.2.1 Reclamation Materials

The primary reclamation materials to be used under this alternative are cover soil and clay. Cover soil would be placed directly on those areas which are determined, by testing, not to have a high potential to generate acidic conditions. Clay materials would be used to cap those areas that tests have determined are capable of producing acidic conditions.

Cover Soil

A layer of cover soil approximately 8 inches thick would be placed on all disturbed areas prior to seeding and planting of shrubs and trees. Sufficient soil to cover all Zortman Mine disturbances with about 4 inches of soil would be obtained from one of three stockpiles: the 82 leach pad site, the South Ruby Saddle stockpile, or the North Ruby Saddle stockpile. Approximate volumes of soil available at these stockpiles are shown on Table 2.5-9. Additional soil would be obtained from Landusky Mine soil stockpiles. Other materials used in reclamation include unconsolidated rock, scree and soil above and below roadway cuts, which are incorporated into the regrading of haul and access roads. Approximate volumes of available cover soil at the Landusky Mine are shown on Table 2.5-10.

Clay

Clay would be required for use in those areas where testing determines that sulfide minerals could create acidic conditions. For reclamation at the Zortman Mine this clay would be mined from the Seaford clay pit approximately 7 miles south of Zortman. At the Landusky Mine clay for use in reclamation would be mined from the Williams clay pit 2 miles west of Landusky.

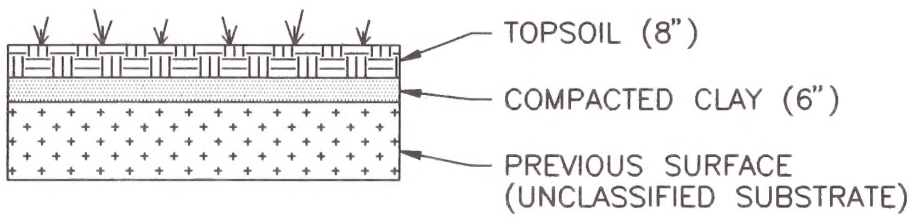
Limestone/Dolomite

Dolomite and limestone from outcrops within the Landusky Mine permit area have most recently been used to provide a 3-foot buffering liner across the floor of the 4,640 bench in the Gold Bug waste rock repository. Non-acid forming waste rock from existing stockpiles have been used as an interim cap on the Mill Gulch waste rock dump and in the Gold Bug waste rock repository, and as a cap on the 91 heap leach pad dike.

2.6.2.2 Reclamation Testing and Covers

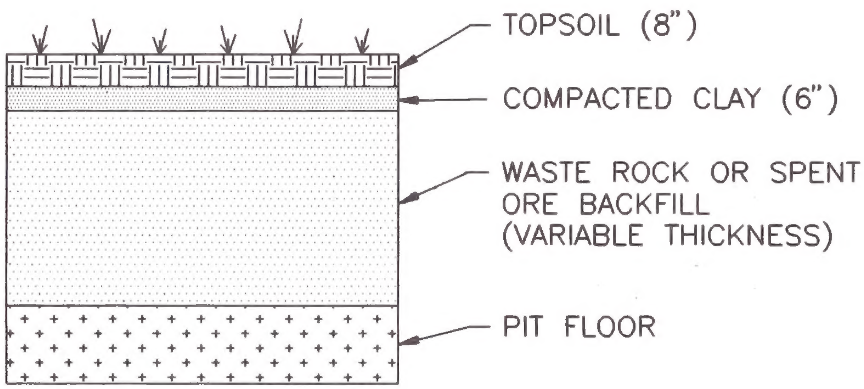
All mine disturbance areas would be tested (except as noted below), on 100 foot centers, to determine the potential for the subsurface to generate acidic conditions. The determination of whether existing mine facilities have the potential to generate acidic conditions would be based on sulfur concentrations. Those disturbance areas which have sulfur concentrations of 0.5 percent or less would be reclaimed with 8 inches of cover soil, as described in Alternative 1.

Those disturbed areas which have total sulfur concentrations greater than 0.5 percent would be capped with Reclamation Cover A, which consists of 6 inches of clay overlain by 8 inches of cover soil. The testing program and reapplication of covers would also apply to disturbances such as the Zortman 79 and 80/81 leach pads and the Landusky 79 leach pad which have reclaimed surfaces. The interim covers already placed on the Mill Gulch waste rock dump, 91 leach pad dike, and Gold Bug waste rock repository would remain as permanent reclamation. These facilities would not require geochemical testing. Figure 2.6-1 illustrates Reclamation Cover A.



WASTE ROCK AND HEAP LEACH
FACILITIES COVER

SCALE: 1"=4'



PIT FLOOR COVER

SCALE: 1"=4'

SOURCE: ZORTMAN MINING INC., 9/94

173E0002

RECLAMATION COVER A
ALTERNATIVE 2

FIG. 2.6-1

2.6.2.3 Mine Pit Reclamation

Overall slope of the final pit walls would be as described in Alternative 1. Pits walls would be approximately 45 degrees (1H:1V) with 30-foot wide flat benches every 60 vertical feet. Pit floors would be sloped and graded to facilitate drainage and alleviate the accumulation of stagnant water.

Two feet of non-acid generating material would be placed on the floor of the mine pit complex. This material would be covered with 6 inches of compacted clay, topped off with 8 inches of cover soil. The surface would then be revegetated in accordance with the procedures described in Section 2.5.2.8. Figure 2.6-1 illustrates the reclamation cover to be used on pit floors under this alternative.

At the Landusky Mine pits drainage would flow toward the August adit with runoff discharging beneath the Montana Gulch waste rock dump. Where possible, pit floors would be cover soiled and revegetated concurrent with mining operations, using trees to the extent possible to reduce visual impact. The Gold Bug pit is being filled with waste rock. Reclamation of that facility would be as described in Alternative 1, Section 2.5.2.5.

2.6.2.4 Leach Pad Reclamation

Tasks associated with reclamation of the heap leach facilities include slope reduction to at least 2H:1V; heap detoxification to reduce cyanide concentrations in the pad to acceptable levels; liner perforation to allow the pads to drain freely into the subsurface; and surface reclamation including geochemical testing, surface preparation, cover placement, and revegetation as described in Alternative 1. Geochemical testing would be conducted on leach pad facilities. Those areas which have sulfur concentrations greater than 0.5 percent would be capped with Reclamation Cover A. This cover would prevent acidic materials from contacting the cover soil and inhibiting vegetative cover.

The current status of heap leach pads at the two mines was described in Alternative 1, Section 2.5.2.4, and summarized on Tables 2.5-3 and 2.5-4.

2.6.2.5 Waste Rock Facilities Reclamation

The additional procedures for reclamation of waste rock dumps would be to test the disturbance areas as described in Section 2.6.2.2. Those areas which have sulfur concentrations greater than 0.5 percent would be capped using Reclamation Cover A to prevent acidic materials from contacting cover soil and inhibiting vegetative cover. Waste rock dumps are to be reduced to a final overall slope of 2H:1V. The reclamation cover on the Mill Gulch waste rock dump and Gold Bug waste rock repository would remain as a permanent cap and surface geochemical testing would not be required. Current status of the waste rock dumps was described in Alternative 1, Section 2.5.2.5. The disturbance area and reclamation status for each waste rock facility was shown on Tables 2.5-6 and 2.5-7.

2.6.2.6 Support Facilities Reclamation

Except where noted, reclamation of support facilities would not change from that described in Alternative 1, Section 2.5.2.6.

Access and Haul Road Reclamation

Haulage and access roadways would be reclaimed to establish suitable drainage. Roadways would be ripped to reduce surface compaction and provide additional fill material for grading of the surface. Haul roads would be tested to determine acid generation potential and covered with Reclamation Cover A if sulfur concentrations exceed 0.5 percent. Roadway berms and loose, unconsolidated material above and below the roadway cut would be pulled or dozed into the roadway using a dozer or backhoe. Final graded areas would be cover soiled and revegetated.

Seaford Clay Pit Reclamation

The Seaford clay pit (shown earlier on Figure 2.5-2) would provide capping materials over those areas containing sulfur concentrations greater than 0.5 percent, which are assumed to be acid generating. Approximately 3 additional acres would be disturbed in the clay pit to obtain the needed quantity of reclamation materials. The clay pit has been reclaimed in accordance with the permit requirements established by the DSL Open Cut Bureau (now part of DEQ). Additional disturbance would have to be reclaimed in accordance with requirements of the Open Cut Act.

Williams Clay Pit Reclamation

The Williams clay pit (shown earlier on Figure 2.5-2) would provide capping materials for those areas containing sulfur concentrations greater than 0.5 percent, which are assumed to be acid generating. Approximately 9 additional acres would be disturbed in the clay pit to obtain the needed quantity of reclamation materials. The clay pit would have to be reclaimed in accordance with requirements of the Open Cut Act.

2.6.2.7 Reclamation Quality Control

Reclamation quality control procedures are not expected to vary from current requirements, although no procedures are specified in the current permit for documenting quality control of reclamation practices. ZMI has used a third-party contractor to perform moisture and density testing of clay covers during installation. Mine personnel periodically drill through the cover to check that minimum thickness is met. Additional clay is added and compacted where needed to maintain thickness. Drill holes are filled with bentonite. Only a visual assessment of cover efficacy is made on pit bench reclamation. ZMI has prepared a QA/QC Program Implementation plan for all new reclamation projects.

2.6.2.8 Revegetation Procedures

Revegetation procedures for this alternative would not be expected to differ from those presented in Alternative 1, Section 2.5.2.8. ZMI uses an independent consultant to monitor revegetation success. The consultant periodically checks vegetation in reclaimed areas to determine if revegetation species have taken hold at the desired density and sustainable viability.

2.6.3 Monitoring Programs and Research Studies

Monitoring programs and research studies already in place or required under the Zortman and Landusky mines operating permits would not be substantively affected by this alternative. Therefore, the description of monitoring programs and research studies provided in Alternative 1, Section 2.5.3 is applicable to this alternative. Potential changes or modifications to those programs are briefly presented in the following sections.

2.6.3.1 Water Resources

The monitoring program for groundwater and surface water would continue as described in Section 2.5.3.1. The only modification anticipated would be the relocation of some monitoring wells or surface water monitoring sites as a result of actions taken to reduce heap leach facility slopes.

2.6.3.2 Reclamation Surface Performance Study

No changes are anticipated to the reclamation surface performance study as a result of implementation of this alternative. It is assumed that Stages 3 and 4 of the RSPS would not be carried forward if the mine expansions are not approved.

2.6.3.3 Other Monitoring Programs

No changes are anticipated to the remainder of the monitoring programs from the descriptions provided in Section 2.5.3.

2.6.4 Reasonably Foreseeable Future Actions

2.6.4.1 Mine Activities

Opportunities for future mining would be as described for Alternative 1 in Section 2.5.4. While this alternative does not preclude proposals for additional mining at either the Landusky or Zortman mines, none are foreseeable.

2.6.4.2 Mine Support Facilities

A permanent facility for storage or disposal of sludges produced by the water treatment plants is foreseeable. No major upgrades to access roads or electrical power service are foreseeable.

2.6.4.3 Exploration Activities

While this alternative does not preclude future proposals for exploration activities, none are anticipated. Since this alternative would not provide for the mining of already delineated ore reserves, the incentive to explore for additional reserve would be very low.

2.7 ALTERNATIVE 3: MINE EXPANSIONS NOT APPROVED AND AGENCY MITIGATED RECLAMATION

This alternative would not approve expansion of the Zortman and Landusky mines, but allows those mine activities already permitted, such as ore leaching and rinsing, to continue. The difference from the No Action Alternative is that this alternative includes agency modifications to the currently approved reclamation procedures at the two mines. Chapter 4.0 of this Final EIS presents an evaluation of the environmental impacts projected to occur using the agency-mitigated reclamation procedures at the two mines.

This alternative has been developed because the current reclamation procedures and those proposed by ZMI in Alternative 2 will not adequately address impacts from acid rock drainage. Additional measures are needed to protect the environment and reclaim the land.

The emphasis of this alternative, as opposed to the other "No Expansion" alternatives, is source control. Many of the reclamation mitigations in this alternative are designed to prevent water contamination by reducing or eliminating contact between water and those waste materials which may react to cause acidic drainage.

This alternative specifies a different type of reclamation cover, called a "water balance cover," to provide better opportunity for the mines to achieve post-reclamation goals. Other modifications have been made to reclamation covers to reduce surface water infiltration, enhance vegetative success, and make more efficient use of available reclamation materials while minimizing disturbance of areas outside the permitted mine boundaries.

This alternative is presented in four main sections:

- Sections 2.7.1 describes the mine operations at the Zortman and Landusky mines. However, since mining under this alternative would not differ from the mining presented in Alternative 1 (Section 2.5.1), the description is limited to a summary of permitted mining operations.

- Sections 2.7.2 describes the reclamation activities required under this alternative for the Zortman and Landusky mines, with emphasis on the mitigated reclamation procedures and modifications.

- Section 2.7.3 describes the monitoring programs in place at the two mines.

- Section 2.7.4 presents an evaluation of future activities which have a reasonably foreseeable opportunity of occurrence under this alternative.

For reference, Figure 2.5-1 and Exhibits 1 and 2 show the current permit boundaries and facilities for both mines.

2.7.1 Mine Expansions Not Approved

This alternative would not approve plans for further mining at the Zortman or Landusky mines beyond that already authorized under the existing permit. Alternative 1 provides a complete description of the currently permitted mining activities, which are summarized below.

No ore has been mined at the Zortman Mine since 1990. Ore which has already been loaded would continue to be leached to extract gold and silver from the rock matrix. The leaching solution would be stored in the pregnant solution holding pond until it is run through the process plant to remove the metals from solution. Spent or barren solution would continue to be recycled for later use in ore heap leaching. Rinsing of the existing leach pads would continue until cyanide concentrations in monitoring locations fall below 0.22 WAD cyanide for a six month period. Final drain-down solution would be piped to the Landusky Mine for use as makeup water or disposed at the Goslin Flats land application area.

Permitted mining operations are nearing completion at the Landusky Mine. No more ore is being removed from the pits. Ore-bearing rock which has been blasted from the Queen Rose, Little Ben, and South Gold Bug

pits is loaded on to the 87/91 heap leach pad for processing. Waste rock generated from the pit is being deposited into the Gold Bug and Queen Rose waste rock repositories in accordance with the waste characterization and handling plan described in Section 2.5.1.1. Ore is loaded onto the 87/91 pad and a cyanide solution is used to extract gold and silver from the rock matrix. The pregnant solution is collected from the bottom of the heap and pumped to a solution storage pond. From there the pregnant solution is processed using Merrill-Crowe or carbon adsorption methods to remove dissolved metals from the solution. The gold and silver is collected, refined into dore, and shipped from the mine to another refinery for further processing. The spent cyanide solution is pumped to a barren pond to be reused in the ore leaching circuit.

Ore leaching is still occurring on the 85/86, 87, 91, and 87/91 leach pads, but the only pads still being loaded are the 91 and 87/91. The 80/81/82, 83, and 84 pads are still being rinsed and will continue until cyanide concentrations in monitoring locations fall below 0.22 WAD cyanide for a six month period. Final draindown solution is to be disposed at the land application area on Gold Bug Butte or transferred to the Zortman Mine via pipeline and disposed at the Goslin Flats LAD area.

2.7.1.1 Water Management

This section presents an overview of water management plans prepared by ZMI, with additional mitigating measures developed by the agencies, to mitigate water quality impacts from mine facility discharges. It includes a description of measures that have been or would be implemented for management of process waters, storm waters and mine drainage. This section is divided into discussions on surface water runoff control, water capture, water treatment and LAD. Additional detail on measures to improve and maintain water quality are contained in the Water Quality Improvement Plan which is presented in Appendix A.

Objective: The objective under this and all other alternatives is to protect beneficial use and to achieve and maintain compliance with water quality standards.

Approach: This alternative relies on a combination of source control and active treatment to protect water quality. Mine waste is segregated and isolated based on acid generating potential. A combination of water balance and water barrier reclamation covers are used to limit infiltration of precipitation into mine waste, thereby restricting water contact with potentially acid generating materials. Diversion of runon water is used to prevent stored acidity within the mine waste from being transported into adjacent surface or ground waters. Capture and treatment of degraded waters is used as a secondary measure to minimize any residual water quality impacts.

The emphasis is to institute source controls, including the removal and isolation of acid generating materials from areas proximal to surface and groundwater. Reclamation covers which would greatly reduce or perhaps eliminate the need for long-term water collection and treatment are required. The management of mine water requires keeping mine drainage, storm water and process waters segregated so that each can be handled using the technology most appropriate to its character.

Surface Water Runoff Control

Interim drainages have been constructed throughout the mining area to route storm water and runoff around the pit complex, leach pads and waste dumps. These interim drainages were built to meet immediate needs of ARD control. As such, they were not intended to deal with flows in excess of a 10-year, 24-hour storm event. Current permit requirements at the Landusky Mine are that diversion drains around critical facilities (waste rock dumps and ore heaps) be sized to convey runoff from a 7-inch, 24-hour storm event at mine closure. Under this alternative, all run-on and run-off drainage ditches be constructed to convey runoff from at least the 6.33-inch, 24-hour storm event. This is the calculated 100-year storm event based on available meteorological data.

Drains carrying storm water are routed to dispersion points consisting of coarse rock filters or sediment control ponds that overflow into natural drainages. Figure 2.5-3 and Figure 2.5-4 illustrate locations of bedrock drains and lined drainage channels. Upgraded drainage ditches would generally be constructed as described in Alternative 1. The lined drainage channels would consist of 6 to 12 inches of compacted clay, which is overlaid with a 10-mil PVC liner, 5-ounce geotextile and 6 to 12 inches of run of mine waste. Bedrock ditches are V-shaped and lined channels are trapezoidal. Maintenance consists of removal of sediment buildup and repositioning of rip rap when necessary.

<u>Zortman Mine Pits</u> - The pit configuration requires bedrock diversions constructed to the east and west to route storm water away from the pits. The pit bottoms would be partially backfilled with mine waste material removed from area drainages that are degrading water quality. Enhanced reclamation covers would be placed over the backfilled pit floor area to limit infiltration of precipitation through this material. The pit floor would

be sloped to not impound runoff in the pit. Currently, water which infiltrates through the mine pit area enters the groundwater system and daylights in Ruby Gulch considerably degraded. This water management approach would prevent precipitation from infiltrating the pit floor and instead route the runoff into Ruby Gulch as surface water. Runoff from the pit highwall would be captured in trenches at the highwall base and treated, if necessary, prior to release in Ruby Gulch.

Landusky Mine Pits - A similar approach would be used at the Landusky pits. Diversions would be constructed to route storm water away from pit disturbance limits. The pit bottoms would be partially backfilled with material removed from area drainages that are impacting water quality. Enhanced reclamation covers would be placed over the backfilled pit floor area to limit infiltration of precipitation through this material, thereby reducing recharge to the August drain tunnel which discharges beneath the Montana Gulch waste rock dump. The pit floor would be sloped to not impound runoff in the pit. A drainage cutout notch would be constructed across the bedrock divide between the August Pit and Montana Gulch. The channel would be sized to handle runoff from a 6.33-inch, 24-hour storm event. Runoff from the pit area would be routed through this channel and along the existing haul road route around the Montana Gulch waste rock dump and 85/86 leach pad. The water would flow into settling/treatment ponds prior to discharging to Montana Gulch below the 85/86 leach pad. Runoff from the pit highwall may be of poor quality and constitute mine drainage. This flow would be captured in trenches at the highwall base and kept separate from storm water which falls on the pit floor. This flow would also be routed to Montana Gulch and treated, if necessary, prior to release.

Leach Pads - Diversion ditches constructed around the leach pads to prevent the inflow of storm water would be upgraded to pass runoff from the 6.33-inch, 24-hour storm event.

At the Zortman Mine, the 85/86 leach pad would be removed from upper Ruby Gulch and used to backfill the mine pits. Discharges exposed in this drainage would be directed to lined channels and routed to the Ruby Gulch capture ponds for possible treatment.

At the Landusky Mine, a drainage trench would be excavated from the side of the west tributary of Montana Gulch that is blocked by the 85/86 leach pad. This would involve excavating approximately 36,000 tons of material with a disturbance of approximately one-quarter acre.

Zortman Waste Rock Dumps - Under this alternative, the existing Alder Gulch waste rock dump would be excavated to remove it as a source of poor quality seepage into Carter and Alder Gulches. After the removal, sediment basins and storm water ponds would be constructed in the dump footprint area to manage any poor quality runoff from the dump site. Material from the dump would be used as pit backfill.

Old mine tailing within the Ruby Gulch drainage would be removed and the channel rehabilitated to reduce sedimentation and enhance riparian vegetation. The tailings would be used as backfill in the mine pits or as construction material in the reclamation covers.

Mill Gulch Dump - No changes would be made to surface water runoff control structure on the Mill Gulch waste rock dump. The existing runoff control structures are adequate for water management purposes.

Gold Bug Waste Repository - No changes would be made to surface water runoff control structure on the Gold Bug waste rock repository. The existing runoff control structures are adequate for water management purposes.

Montana Gulch Waste Dump - Portions of the Montana Gulch waste rock dump could be removed for use as pit backfill or as reclamation cover over other mine facilities. The remaining waste rock dump runoff control structures would be upgraded to pass flow from 6.33-inch, 24-hour storm event.

Water Capture

The location of water capture structures would remain as described in Alternative 1. Implementation of this alternative could result in a decrease of mine water requiring capture, due to improved diversion of runon waters and reduction in infiltration from the enhanced reclamation covers. However, the quality of the capture water may also become worse without dilution. Existing capture and treatment systems would be expanded to capture and retain seepage associated with a 6.33-inch, 24-hour storm event. This would constitute an upgrade from the current capacity of most facilities to capture and retain seepage from a 2.5-inch, 24-hour storm event.

All leach pad solution and capture ponds would be enclosed with 8-foot fencing capable of excluding big game and other large animals from potentially contaminated water.

Additional information concerning the capture systems is found in the Water Quality Improvement Plan, Appendix A.

Water Treatment

The location and function of the water treatment plants would remain as described in Alternative 1 and Appendix A. ZMI constructed a 2,000-gpm water treatment plant in May 1994 to treat seepage water captured at the toe of existing mine waste rock dumps at the Zortman Mine. The plant operates at a rate of 200 to 2,000 gpm depending on factors such as precipitation amounts and seasonal operating conditions. Another water treatment plant is planned for the Landusky Mine and would be located in the Montana Gulch area. Interim effluent discharge standards from the plant are BAT for mine waters (40 CFR §440.100). Establishment of final effluent limits and outfall points would occur as part of MPDES permit development.

The water treatment plants would continue to operate until final reclamation measures have successfully produced effluent that meets the water quality standards. Under Alternative 3, with the placement of enhanced reclamation covers, long-term capture and treatment may not be necessary to meet water quality objectives in many, or possibly all, of the affected drainages. However it is included in Alternative 3 as a mitigation for residual water quality impacts.

Land Application Disposal

The location and operation of the land application areas would not change from Alternative 1. Provisions for land application disposal are required by the regulatory agencies for final heap draindown at mine closure, or in the case of an extreme precipitation event that overwhelms the capacity of the leaching circuit. In the land application process leaching solutions are treated with either hypochlorite or hydrogen peroxide to detoxify the cyanide. All solutions must be at or below 0.22 mg/l WAD cyanide prior to land application. Use of land application as a water management practice requires advanced notification and review by the regulatory agencies prior to each land application event to verify the character of the applied solutions, remaining soil attenuation capacity, and necessary monitoring techniques.

2.7.2 Agency Mitigated Reclamation

The agencies have developed modifications to ZMI's proposed reclamation plans described in Alternative 2, which would: (1) reduce infiltration into areas with the potential to cause acidic drainage, (2) remove waste rock dumps and other sources currently causing degradation of surface water or groundwater, and (3) implement a Water Quality Improvement Plan to further mitigate effects of ARD should reclamation procedures fail to adequately protect environmental resources. The major reclamation modifications are summarized below.

- To limit surface water infiltration and provide a better media for revegetation, water balance and water barrier reclamation covers (see Figure 2.7-1) would be used instead of the reclamation covers proposed by ZMI in Alternative 2.

- Unless specifically identified below, mine waste rock facilities and ore heaps are assumed to be acid generating and would be reclaimed using the reclamation covers specified in Section 2.7.2.2. Cover soil on the facilities would be removed, stockpiled, and reused.

- With the exception of most leach pad dikes, existing facilities would be reclaimed to an overall 3H:1V slope with constructed benches every 100 vertical feet between benches. This measure would reduce erosion and soil loss, increase overall surface reclamation success, and result in more stable facilities. In order to achieve the slope reductions while minimizing additional land disturbance in adjacent drainages, some material may have to be off-loaded from existing facilities and backfilled into the pit.

- To enhance the probability of long-term reclamation success, soil loss from reclaimed areas must be less than 2 tons/acre/year.

- In order to classify as "Non-Acid Generating" (NAG) and be used without restriction in construction and reclamation, thereby ensuring the potentially acid generating materials are not placed in areas potentially exposed to surface water and the open atmosphere, waste rock:

  1. Cannot be composed of breccia, felsic gneiss, monzonite, quartzite, or trachyte lithologies;

  2. If amphibolite, mafic gneiss, shale, dolomite, or limestone must have a total sulfur content less than or equal to 0.8 percent, and a Paste pH of 6.0 or greater;

  3. If syenite, must have a total sulfur content less than or equal to 0.2 percent, a Paste pH of 6.5 or greater, and an NNP of 0 or greater;

  4. Must meet the criteria above as demonstrated by sampling and analyzing lithologies from every blasthole providing non-acid generating material for total sulfur, Paste pH and NP. All

blastholes within a discrete mineable block (25 feet x 25 feet) must meet these criteria.

5. If syenite, can only be used in reclamation covers and not for fill or other construction.

- To ensure that only non-acid generating materials are used in facilities transporting surface water or seepage water, material used as capillary break/drainage layers may be obtained from the unmineralized sources specified in Section 2.7.2.1.

- Rock underdrains would be built with durable, unmineralized limestone, as an additional precaution to buffer acidic drainage.

- No trees would be used in revegetation except on a limited basis for visual impact mitigation. Only grasses, forbs and shrubs would be used to enhance wildlife habitat. Crested wheatgrass could not be used in the reclamation seed mix.

- Vegetative cover must achieve 90 percent of that demonstrated in adjacent, natural communities of similar composition and location to be considered acceptable.

- An expanded monitoring program would be implemented, as described in Section 2.7.3, and reclamation viability would be monitored by ZMI until the agencies have approved final closure and released the mine reclamation bond.

<u>Zortman Mine</u>

- The Zortman Mine pits would be backfilled to about the 4,900-foot level and graded so that runoff freely drains, without impoundment in the pit, into the Ruby Gulch drainage.

- The existing Alder Gulch waste rock dump would be removed and used to backfill the pit complex. The cover soil would be re-salvaged and the waste rock footprint reclaimed using this material.

- After detoxification, the Zortman 85/86 leach pad and dike would be removed to create a free draining surface and placed in the pit as backfill material prior to pit floor reclamation.

- The OK waste rock dump would be removed and used to backfill the pit complex or used as reclamation material. Cover soil would be re-salvaged and the waste rock footprint reclaimed.

- The sulfide storage area in Ruby Gulch would also be removed and used as backfill in the pit complex.

- The tailing in Ruby Gulch above the town of Zortman would be removed from the drainage and used in reclamation covers. The drainage would be restored as mitigation for existing disturbance to waters of the United States by other Zortman and Landusky mines facilities.

<u>Landusky Mine</u>

- The Landusky 91 leach pad dike would be re-reclaimed as appropriate to allow redistribution of spent ore to the south, west and east of the 87/91 pad. This action would eliminate the potential for surface water from the 87/91 pad to runoff north of the mine site into drainages on the Fort Belknap Reservation.

- Existing reclamation covers on the Gold Bug waste rock repository and the Mill Gulch waste rock dump may require supplemental cover soil to meet the performance criterion for limiting infiltration.

- The Landusky mine pits would be backfilled to a minimum elevation of 4,740 feet (at the south end of the pit complex/drainage ditch) to create a surface which will freely drain into Montana Gulch, thereby reducing the potential for precipitation and surface water runon to infiltrate through acidic materials and into the groundwater. Less than 3.6 million tons of backfill would be required to reach this level (ZMI 1996). Material used in backfill would come from existing waste rock dumps and leach pads, mined waste rock, or construction of the drainage channel.

- Runoff from the Queen Rose/Suprise and August/Little Ben pit areas would directed through a drainage notch between the August/Little Ben pit and Montana Gulch. Surface water would be routed to Montana Gulch immediately below the waste rock dump.

- To unblock surface water drainage in the western tributary of Montana Gulch a drainage channel would be constructed along the west margin of the 85/86 leach pad.

2.7.2.1 Reclamation Materials

Reclamation materials would be required for construction and installation of reclamation covers, and for use in construction of drains and diversions. The primary reclamation materials to be used under this

alternative are cover soil, subsoils, non-acid generating materials such as gravels, limestone, and possibly waste rock. In addition, the water barrier covers incorporate the use of a geosynthetic clay liner (known as "GCL").

Figure 2.7-1 displays the reclamation covers that would be used under this alternative. A brief description of the uses for and availability of these materials follows.

Non-Acid Forming Material

Non-acid forming material would be used primarily as a capillary break/drain layer in water barrier reclamation covers, and to a lesser extent as rip-rap and as drain rock. The reclamation covers used in this alternative require a capillary break of 36 inches to be composed of a suitable non-acid generating material such as colluvial gravel, Ruby Gulch tailing, or limestone. If additional subsoil is available (after incorporation into the water balance covers) it would be preferred for use as NAG in the water barrier covers.

Non-acid forming material to be used in the water barrier cover would come from the following sources, listed in order of preference:

Zortman Mine

Ruby Gulch Tailing
Goslin Flats Borrow Source
LS-2 Limestone Quarry

Landusky Mine

Montana Gulch Waste Rock Dump
Montana Gulch Limestone Quarry
August #2 Waste Rock Dump

Sufficient supplies of these materials are available at the above sources for Alternative 3 (see Section 4.1.4).

Non-acid forming waste rock is being used as an interim cap on the Mill Gulch waste rock dump, in the Gold Bug waste rock repository, and as a cap on the Landusky 91 heap leach pad dike. Waste rock used in these facilities comes from existing stockpiles and that generated by the ongoing mine operation.

Tailing

The Ruby Gulch tailing must be removed as a mitigation measure. The Ruby Gulch tailing provides a ready source of material suitable for use in reclamation covers, either as a subsoil or a drain layer. Field studies conducted during the latter part of 1995 suggest there are about 600,000 yd^3 of available tailing in the portion of Ruby Gulch extending from the new capture ponds adjacent to the mine, down to the mine gate just above the town of Zortman (Womack 1995 and Ryan 1996). Additional materials may be available from below the gate if they need to be removed for channel reconstruction.

Limestone/Dolomite

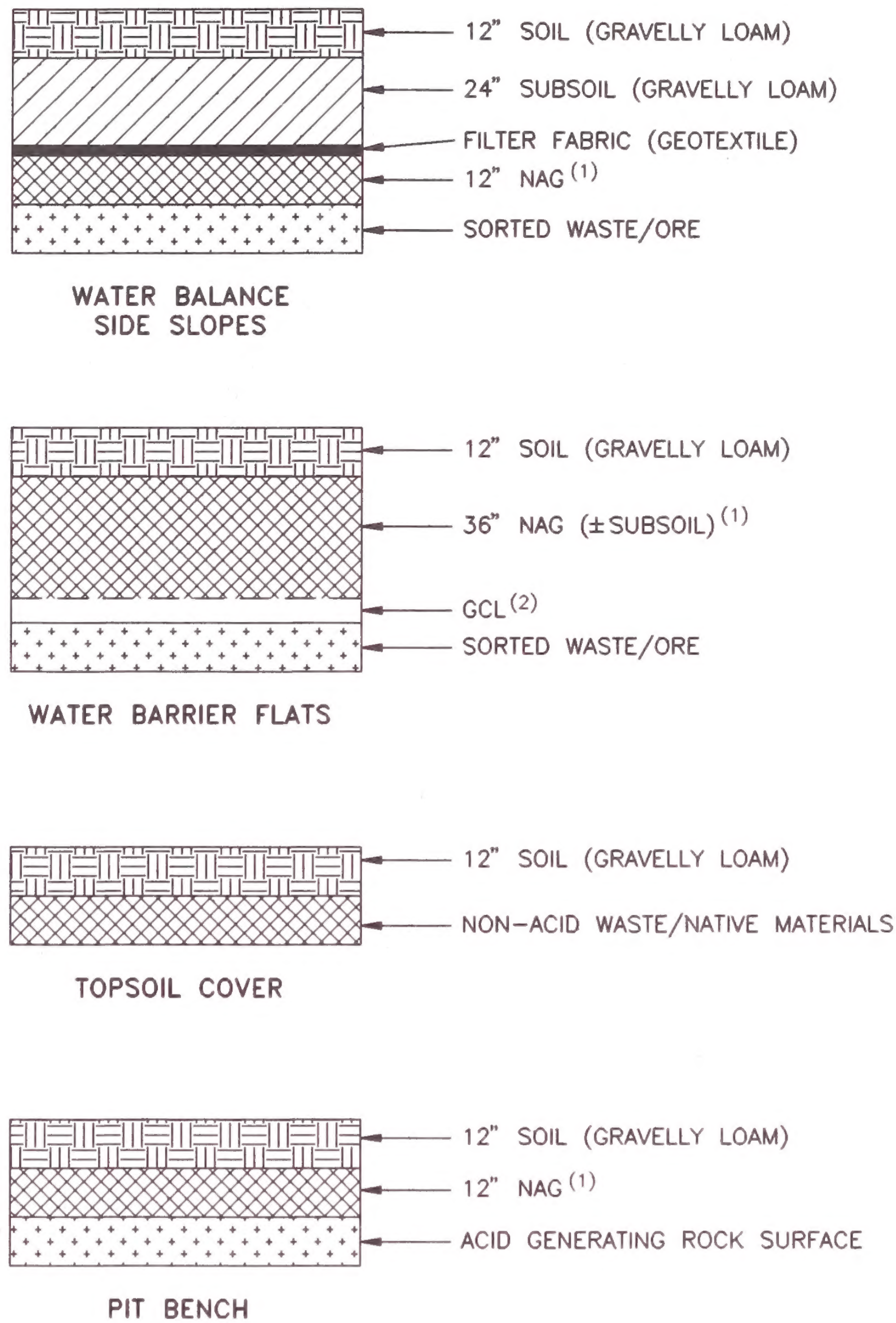
If limestone is used in reclamation covers, it would be mined from LS-2, a quarry location west of the town of Zortman (see Figure 2.5-2). Limestone would be mined using drill and blast mine methods. Haul trucks would transport the limestone from the quarry to the Zortman Mine along the route shown in Figure 2.5-2. A road to this site exists, but it would likely need upgrading and widening. These activities would require pushing the cover soil downhill and using it as a catch bench on slopes no steeper than 2H:1V. The road would then be cut to an approximate 50-foot width. In areas steeper than 2H:1V no cover soil would be placed in side cuts.

Limestone and dolomite have been used on a limited basis at the Landusky Mine, primarily when mined as waste rock associated with ore. Because of their high carbonate content, both of these rock types are useful to neutralize acidic conditions. Dolomite and limestone from outcrops within the mine permit area have recently been used to provide a 3-foot buffering liner across the floor of the 4,640 bench in the Gold Bug waste rock repository. Limestone and dolomite from the mine pits could also be used as capillary break material in the reclamation covers. A source of limestone exists at the Montana Gulch area on about 10 acres north of Landusky (see Figure 2.5-2).

Subsoils, Gravels and Colluvial Material

To provide sufficient quantities of subsoil for the water balance covers, it will be necessary to use Goslin Flats as a borrow source. This area east of Saddle Butte has been investigated by ZMI for use as a leach pad (under Alternatives 4, 6, and 7) and land application disposal area (Alternatives 1, 2, 3, and 5). These studies have indicated that approximately 2.2 million yd^3 of suitable subsoil could be mined from an area of about 210 acres, down to an average approximate depth of 10 feet. The subsoil and other gravels and colluvial material at the Goslin Flats provide a sufficient source of capillary break in the water barrier reclamation covers.

ZMI has identified another source of subsoil material south of Landusky, on about 55 acres called the Rock Creek flats. This location is currently undisturbed, but it could provide another 130,000 yd^3 of subsoil. However, this source should not be needed, and should remain undisturbed unless the other sources indicated above are not sufficient for the reclamation program.



NOTES:

1. NAG – NON ACID GENERATING MATERIAL

2. GCL – GEOSYNTHETIC CLAY LINER.

ALTERNATIVES 3 AND 7
WATER BALANCE RECLAMATION COVERS
FOR ZORTMAN-LANDUSKY MINES

173E0024

FIG. 2.7-1

Cover Soil

Cover soil would be used on top of mine disturbances, either as a final 12-inch lift on the reclamation covers or as 12-inch layers directly overlying disturbed zones which are determined not to have significant acid generating potential. Cover soil for reclamation at the Zortman Mine is obtained from one of three stockpiles: the 82 leach pad site, the South Ruby Saddle stockpile, or the North Ruby Saddle stockpile. The approximate total volume of soil available at these stockpiles is 182,000 yd^3 as shown on Table 2.5-9.

At the Landusky Mine, cover soil is obtained from one of four cover soil storage areas: the Mill Gulch stockpile, part of the Mill Gulch waste rock dump; the Little Ben soil stockpile; the Gold Bug soil stockpile; and the Montana Gulch soil stockpile. Approximate volumes of soil available at these stockpiles are 2.17 million yd^3, as shown on Table 2.5-10.

Based on the estimated amount available in stockpiles, a layer of cover soil approximately 4 inches thick could be used on all disturbed areas at the Zortman Mine. Because this is an insufficient thickness of cover soil, ZMI must use excess cover soil from the Landusky Mine and, if necessary, remove sufficient quantities of cover soils from the Goslin Flats land application area. Based on the estimated amount available in stockpiles, sufficient cover soil exists at the Landusky Mine to be used in surface reclamation of all facilities. Excess cover soil could be used at the Zortman Mine, if insufficient quantities are available there. Cover soil would either be placed directly on graded areas prior to revegetation, or spread on top of the clay cap where potentially acid generating material is to be capped.

Goslin Flats would need to be mined to provide subsoil for reclamation covers. Based on investigations conducted by ZMI, it is estimated there are 567,000 yd^3 of suitable topsoil available from the 210 acre area at the Goslin Flats. (This does not include all supplies from this area; some would be used to reclaim the cover soil borrow area).

Another source of cover soil is the material salvaged during re-reclamation activities on facilities which have already been cover soiled and revegetated. Other materials used in reclamation include unconsolidated rock, scree and soil above and below roadway cuts, which are incorporated into the regrading of haul and access roads.

Geosynthetic Clay Liner

A GCL is essentially a combination of a thin bentonite clay layer sandwiched between two woven, synthetic layers called geotextiles. The bentonite provides a seal between the geotextiles. When the bentonite is exposed to moisture it swells, providing added protection against leaks or cracks. Enhanced reclamation covers used on surfaces with a slope less than 25 percent would use the GCL.

2.7.2.2 Reclamation Testing and Covers

Instead of relying on geochemical characterization of areas to be reclaimed, most of the waste rock and spent ore heap facilities are assumed to contain potentially acid-generating materials and require enhanced reclamation covers to limit surface water infiltration. Those disturbances with a slope greater than 25 percent would be reclaimed using a water balance cover. Those areas with less slope than 25 percent would be reclaimed using a water barrier cover. Pit benches would be covered using soil and NAG material, while the remaining disturbances would be reclaimed with topsoil. Figure 2.7-1 illustrates the reclamation covers used under this Alternative. Specific discussions of individual facilities are in the following sections.

The other modification to reclamation covers is in the definition of "NAG" material. The criteria for material to be suitable for use in capillary break were described at the beginning of Section 2.7.2. Certain rock types would be excluded from use and those not excluded must demonstrate a sufficiently high Paste pH, sufficiently low sulfur content, and appropriate neutralization potential. All waste rock considered for use as NAG material must come from blastholes or dumps which have been characterized according to these criteria. However, it is anticipated that waste rock from mining would not be needed for reclamation. As described in Section 2.7.2.1, sufficient suitable materials for subsoils and capillary break may be obtained from sources such as the Ruby Gulch tailing, Goslin Flats borrow area, and existing stockpiles. The Montana Gulch and August No. 2 waste rock dumps may also provide suitable material for capillary break at the Landusky Mine facilities. Material used for capillary break must be of a suitable geochemical composition to insure the clay integrity is not compromised, particularly from pore water too high in calcium or magnesium.

Water Balance Covers

Procedures used to cover disturbed areas with slopes greater than 25 percent would be significantly different than described in Alternatives 1 or 2, or in the Company Proposed Action (Alternative 4). Water balance covers are designed to limit the amount of moisture reaching

the waste zone by maximizing evapotranspiration. The top 36 inches of the cover consists of topsoil (12 inches) and subsoils (24 inches) to provide water storage capacity and a good substrate for vegetative rooting. Thus, most water is taken up by vegetation or lost to the atmosphere. Any residual water in the capillary break (the 12-inch zone of NAG material) would drain laterally to collection sumps. A filter fabric would be placed on top of the capillary break to limit downward migration of fine grained particles which could clog the capillary break drainage capacity. A GCL would not be necessary for this reclamation cover because of the decreased potential for surface water infiltration, due in part to the increased water holding capacity and evapotranspiration provided by reclaimed surfaces.

Water Barrier Covers

Water barrier covers limit the downward migration of water into the waste zone by using low permeability materials such as compacted clay, geotextiles, or synthetics like PVC. For this application, water barrier covers would be installed on flat or gently sloping (less than 25 percent) disturbances assumed to be acid generating. Facilities such as backfilled pit surfaces, waste rock facility surfaces, ore processing areas, and some haul roads would be expected to need a water barrier cover. Unlike the water balance cover, the barrier cover shown in Figure 2.7-1 incorporates a GCL underneath soil, subsoil and/or NAG material. The GCL is needed to provide additional assurance that surface water will not seep into the potentially acid generating material underneath. Infiltration water is of more concern on the gently sloping surfaces because surface water will be more likely to pond and less likely to runoff.

For this cover, 12 inches of subsoil is underlain by 36 inches of suitable NAG material. The NAG layer serves as a drain layer should infiltration water accumulate above the GCL. It also provides the amount of cover needed to achieve a 4-foot thickness over potentially acid generating areas. Only 1 foot of coarse material is needed to function as a drain layer, and the upper 24 inches could be constructed with subsoil. Subsoil would be used in this layer to the extent there is excess available after application in all water balance covers. If sufficient subsoil quantities are not available, other NAG material such as limestone, suitable waste rock, or tailing can be used in this layer.

Pit Bench Covers

Pit benches are assumed to be a significant acid generating source, but it is problematic to reclaim pit benches consistent with the two reclamation covers described above. Access and working space is difficult, and it is therefore impractical to require installation of, for instance, a GCL on such a surface. Instead, pit benches must be covered using 12 inches of topsoil on top of 12 more inches of suitable NAG material. This will provide a base for vegetation to take root. As described later in this section, emphasis will be placed on keeping water off of the pit benches using surface water diversions above the pits, and to control water which does come into contact with the benches or highwalls by use of a capture system at the base of highwalls.

Topsoil Covers

The remaining areas which are not constructed on or of potentially acid generating materials such as some shops, topsoil stockpiles, and some haul roads, would be covered with 12 inches of topsoil to provide a suitable substrate for vegetative growth. The determination on whether to use topsoil, or a more protective type reclamation cover would be based on total sulfur concentrations. Those areas disturbed for haul roads or other facilities with sulfur concentrations greater than 0.5 percent would be capped with a water balance or water barrier cover, depending on the surface slope. Disturbances with lower sulfur concentrations would be covered only with 12 inches of cover soil.

2.7.2.3 Mine Pit Reclamation

Overall slope of the final pit walls would be approximately 45 degrees (1H:1V) with 30-foot flat benches every 60 vertical feet. Pit floors are to be sloped and graded to facilitate free drainage. No surface water from the pits or collected as storm water around the pits would be allowed to drain to the north, but would be routed to central capture systems for eventual discharge in southern drainages. The final pit floor (i.e., the backfilled surface) would be covered with the water barrier cover shown in Figure 2.7-1 to reduce surface water infiltration. This alternative requires the placement of limited covers on pit benches. Revegetation (where revegetation is possible) of benches would include the use of trees to the extent possible to reduce visual impacts.

Zortman Mine Pit

This alternative requires that waste rock and spent ore from a number of facilities be placed as backfill into the Zortman pit complex. The purpose of this action would be to remove those facilities known or suspected to be contributing to contamination of water resources in the vicinity of the Zortman Mine. The facilities to be off-loaded and backfilled into the Zortman pit include:

Facility	Estimated Load
Alder Gulch waste rock dump	3.4 million tons
Ruby Gulch sulfide storage	0.9 million tons
85/86 leach pad and dike	8.5 million tons
OK waste rock dump	1.2 million tons
	14.0 million tons

The addition of this material would backfill the pit to an elevation of about 4,900 feet mean sea level (msl) or higher, creating a surface which freely drains out of the pit into Ruby Gulch where water capture systems could collect runoff and, if necessary, route it to the Zortman water treatment plant prior to discharge. Pit benches not covered by backfill would be covered with 12 inches of NAG material and 12 inches of topsoil, and revegetated where possible, to include tree planting to reduce visual impacts of highwalls.

Landusky Mine Pit

At the Landusky Mine, a number of mitigations in this alternative modify pit reclamation requirements. The pits would be backfilled to a minimum elevation of 4,740 feet msl, measured at the south end of the August pit, to create a surface which would freely drain into Montana Gulch. This action would decrease the potential for acid drainage to form by reducing the potential for surface water to enter the pits and contact sulfide-bearing zones. Backfill within the pit complex would be sloped at approximately 2 percent or greater to drain surface water to the exit channel at the south end. Material used as backfill would come from the Montana Gulch waste rock dump, or construction of the drainage cutout to Montana Gulch, described below.

A drainage cutout would be constructed across the bedrock divide between the August/Little Ben pits and Montana Gulch, thereby preventing surface water from infiltrating to the August tunnel and redirecting flow to Montana Gulch. Rock removed during construction of the drainage notch would be backfilled into the August pit. The cutout excavation would continue until materials balance to achieve an average gradient of 2 percent throughout the constructed drainage. An estimated 3 to 4 million tons of rock would be removed from the notch for this project. Any ore-grade material encountered during excavation of the notch could be transported to the 87/91 leach pad for processing, if an engineering analysis determines extra loading would not result in unstable conditions.

2.7.2.4 Leach Pad Reclamation

Leach pad reclamation would differ significantly from the procedures described for Alternatives 1 and 2 both in terms of whether the leaching facilities would be left in-place, and the type of reclamation cover.

Zortman Mine Leach Pads

The Zortman 85/86 heap leach pad and dike would be removed and placed as backfill into the Zortman pit complex. The facility footprint would be tested on 100-foot centers. Those areas with total sulfur content greater than 0.5 percent sulfur would be covered, depending on slope, with a water balance cover (greater than 25 percent) or water barrier cover (less than 25 percent) and revegetated. Areas with lower sulfur contents would be scarified, covered with 12 inches of soil, and revegetated.

Water balance and water barrier covers would be placed on all other existing leach pads, including those such as the Zortman 79 and 80/81 pads which have been reclaimed under existing reclamation requirements. Leach pad slopes would be reduced to overall 3H:1V to further limit surface water infiltration, stabilize cover soil, and enhance the potential for successful revegetation. The 84 leach pad dike would not be reduced in slope. Remaining leach pad dikes would be reduced to a slope sufficient to allow placement and retention of the water balance cover.

Landusky Mine Leach Pads

Water balance and water barrier covers would be installed on all leach pad disturbances, including those such as the Landusky 79 leach pad which have been reclaimed under existing reclamation requirements. Leach pad slopes would be reduced to overall 3H:1V to further limit surface water infiltration, stabilize cover soil, and enhance the potential for successful revegetation. Constructed 25-foot wide benches must be placed every 100 vertical feet. Leach pad dikes would not be reduced in slope, unless other modifications are made to the pad and dike for use in pit backfill or drainage control.

The 87/91 leach pad would be reconfigured prior to final reclamation to reduce the potential for surface water drainage to exit north of the divide. Spent ore on the north side, near the north-south drainage divide, would be pulled back or moved to the east, south, or west areas of the pad. About 4 million tons of spent ore would be redistributed. Overall reclaimed slope of the entire facility would be 3:1, with 25-foot benches every 100 vertical feet. The containment dike for the 91 ore

heap must be reduced to a 2.5H:1V slope or less to facilitate ore redistribution, and limit infiltration of precipitation and surface water (DSL/BLM 1994a).

Other tasks associated with reclamation of the heap leach facilities include heap detoxification, surface reclamation, and liner perforation. The basic procedures associated with each of these tasks for this alternative were described in Section 2.5.2.4 and apply to this alternative, as summarized below.

Heap Detoxification

Spend ore on the leach pad would be rinsed repeatedly with cyanide-free water to enhance degradation of cyanide compounds left in the heap. Heap detoxification is discontinued when the solutions returning from the heap maintain less than 0.22 mg/l cyanide (measured as WAD cyanide) for a six-month period which includes a spring, high-flow surface runoff event. Heap draindown solutions from the Zortman Mine could be transported via pipeline to the Landusky Mine for use in the processing circuit, since ore leaching will continue for a longer period at that mine. Alternatively, heap solutions remaining after detoxification would be pumped to a containment pond for neutralization and later land application disposal. The use of a land disposal facility for heap draindown solutions would be planned and conducted in accordance with the procedures described in Section 2.5.2.4.

Surface Reclamation

After the existing heap leach pads are detoxified, or concurrent with detoxification, surface grading begins to reduce pad slopes to an overall 3H:1V slope. Constructed benches must be placed every 100 feet of vertical spacing. Slope reduction is performed by track mounted bulldozers pushing ore heap material from the facility crest or top down over the lift slopes, using cut and fill material from each of the heap benches to obtain the desired slope. To achieve the desired 3H:1V slopes, off-loading of material would likely be required from some facilities. This would be done using loaders and haul trucks, and the off-loaded material would be dumped into the pits as backfill. Leach pad surfaces would be capped with water balance and water barrier covers, depending on the slope of the surface are, then revegetated.

Heap retaining dikes requiring reclamation would be reduced to a nominal slope of 2.5H:1V, or sufficient to allow placement and retention of the water balance cover. The dike faces would be capped with the water balance cover and revegetated to blend with existing undisturbed contact zones and reestablish vegetative communities.

Liner Perforation

After the leach pad has been detoxified and the surface reclaimed, the pad liner is perforated to reduce storage within the heap of precipitation and surface water runon. ZMI would conduct the following activities prior to liner perforation:

1. Water in the sumps of reclaimed leach pads would be sampled on an annual basis. These samples would be analyzed for the complete list of analytes shown on Table 2.5-18. Additional sampling of sump water monthly would include analysis for sulfates, total cyanide, pH, conductivity, total dissolved solids, total hardness as $CaCO_3$, and alkalinity as $CaCO_3$.

2. The rate of phreatic surface rise would be monitored on a monthly basis for the first three years prior to liner perforation by measurement of phreatic surface elevations. Based on these measurements, the rate of infiltration into a reclaimed leach pad would be calculated. Monitoring frequency may be reduced if sufficient data has been collected to establish the in-heap hydraulic conditions.

3. After 10 years, if it is determined that water quality management objectives would be met for a given leach pad, the liner for that facility would be perforated.

4. If monitoring indicates that water quality management objectives would not be met, or if the rate of accumulation is such that dewatering of the leach pads becomes necessary before the 10-year monitoring period is reached, heap waters would be treated and/or discharged using the land application area.

It is estimated that 3 to 4 drain holes 6-inches in diameter would be drilled into the underlying drainage system to provide an exit for solution within the heap. Each perforated drain hole is backfilled with drain rock to an elevation of at least 5 feet above the liner surface to ensure continued drainage. The drain holes would be positioned at the lowest elevation in the pad collection basin to provide for adequate drainage and prevent the formation of undesirable hydraulic conditions within the heap. The number of perforation holes drilled in each leach pad liner would be sufficient to ensure that the in-heap water level completely drains within 48 hours of reaching the static level. This is to ensure that water collected in leach pads during storm events does not remain in extended contact with acid generating minerals or residual cyanide compounds. In addition,

this would help reduce the potential for failure of pad retaining structures caused by hydraulic pressure.

2.7.2.5 Waste Rock Facilities Reclamation

Waste rock currently in dumps at the Zortman Mine would be removed and placed as backfill into the existing pit complex. It is estimated that 5.5 million tons of material would be excavated and backfilled. The footprints from the waste rock dumps would be tested on 100-foot centers. Those areas with total sulfur content greater than 0.5 percent sulfur would be capped with water balance or water barrier covers, depending on the surface slope. The cover surface would be revegetated.

The interim covers already constructed on the Mill Gulch and Gold Bug waste rock facilities would remain as permanent reclamation caps, provided that the infiltration performance criteria are met. Additional soil could be added to these covers to reduce water infiltration rates.

Part of the Montana Gulch waste rock dump could be removed and used as backfill in the pit. The remaining footprint would be tested and reclaimed with the appropriated water balance or water barrier cover if sulfur concentrations exceed 0.5 percent. Reclamation Cover C would continue to be used on the Gold Bug waste rock repository and backfilled pit. Reclaimed surfaces would be revegetated in accordance with Section 2.8.2.8, except where modified as described in Section 2.7.2.8.

2.7.2.6 Support Facilities Reclamation

Unless otherwise noted in the following sections, reclamation of support facilities would not change from that described in Section 2.5.2.6. Final reclamation would include the removal of all structures and equipment used in the mining and processing of ore through heap leach operations. All cement structure footings and pads would be removed and used to help backfill depressions or openings such as ponds, or would be disposed appropriately as solid waste. The footprint of removed facilities would be covered with 12 inches of cover soil and revegetated.

Solution/Process Pond Reclamation

Reclamation of solution and process ponds would not differ from that described in Alternative 1 (Section 2.5.2.6), except that the backfilled ponds would be covered with 12 inches of cover soil prior to revegetation.

Process Plant Site Reclamation

Final reclamation would include the removal of all structures and equipment used in the mining and processing of ore through heap leach operations. All footprints from these facilities and areas contaminated by spillage of non-oxide ore would be tested on 100-foot centers for total sulfur prior to reclamation activities. Surfaces found to contain greater than 0.5 percent sulfur would be capped with a water barrier cover, as shown on Figure 2.7-1. Other areas would be capped with 12 inches of cover soil and revegetated. An expanded discussion of reclamation requirements for the process plant sites, applicable to this alternative except for the reclamation cover requirements, is found in Section 2.8.2.6.

Soil Stockpile Reclamation

Cover soil stockpiles may be depleted by the time surface reclamation activities are finished. The footprints from the soil stockpiles would be tested on 100-foot centers. Those areas with total sulfur content greater than 0.5 percent sulfur would be covered with a water balance or water barrier cover, depending on surface slope. Areas with less than 0.5 percent sulfur would be capped with 12 inches of cover soil. All reclaimed surfaces would be revegetated.

Access and Haul Road Reclamation

Haul and access roadways would be reclaimed to establish suitable drainage. Roadways would be ripped to reduce surface compaction and provide additional fill material for grading of the surface. Roads would be tested to determine acid generation potential and covered with clay, if necessary. Roadway berms and loose, unconsolidated material above and below the roadway cut would be pulled or dozed into the roadway using a dozer or backhoe. Other sampling, reclamation, and revegetation requirements for haul and access roads would be as described in Alternative 4, except that water barrier or water balance covers, as shown on Figure 2.7-1, would be used on surfaces with sulfur contents exceeding 0.5 percent.

Land Application Area

Reclamation of land application areas would not differ from Alternative 1, as described in Section 2.5.2.6.

Limestone Quarry Reclamation

It is anticipated that some limestone could be required to supplement the materials available for use as capillary break in the water barrier cover and for the NAG layer on pit benches. This limestone would be mined from a quarry northwest of the town of Zortman known as LS-2, in the south portion of ZMI's permitted mine area (see Figure 2.5-2). Reclamation of this site would include regrading, topsoil application, and revegetation.

At Landusky, limestone needed for reclamation or drainage structures would be mined from a quarry located southwest of the mine facilities (but still in the permitted mine boundary) known as the Montana Gulch limestone quarry. Reclamation of this site would include regrading, topsoil application, and revegetation.

2.7.2.7 Reclamation Quality Control

ZMI, or a mine contractor overseen by ZMI personnel, would install the capillary break used in the water barrier cover. The capillary break thickness would be at least 3 feet over 95 percent of the area covered, with a minimum thickness of 2.5 feet at any location. The capillary break would consist of material which meets the rock type and geochemical characteristics for NAG material described in Section 2.7.2.1.

ZMI or a contractor would install the GCL. The installation would be monitored by a qualified independent third party contractor engineering firm experienced in the oversight of GCL installation.

The GCL is manufactured in large panels, bound into rolls for delivery to the site on flat bed tractor trailer trucks. The panels are unrolled at the installation area and placed on a prepared subgrade. Adjoining panels are overlapped and granular bentonite is placed between the overlapping panels. The GCL is hydrated with clean water; the bentonite is allowed to hydrate for a period of time; and then the GCL is overlain with a soil cover.

A properly installed GCL has a permeability of about 1×10^{-9} or greater. To maintain a quality construction, the GCL would be installed in accordance with the manufacturers specifications. Manufacturers Quality Assurance/Quality Control (QA/QC) guidelines for the proper installation of GCL liners typically include the following:

- Size and Type of equipment used to handle and install the GCL
- Foundation preparation and acceptance criteria
- Methods for GCL handling and deployment
- Panel layout and orientation
- Seaming
- Hydration
- Soil cover material type and placement method

The field engineer representing the third-party oversight contractor would be experienced in the installation of a GCL and would keep a daily written record of the installation, including documentation of quality control testing. The quality control testing would follow the manufacturers specifications and include the following testing:

- Bentonite Mass per unit area for the GCL
- Bentonite Free Swell
- Bentonite mass per unit length of seam

Monthly construction reports with testing results would be provided to the agencies.

2.7.2.8 Revegetation Procedures

Revegetation procedures would be essentially as presented in Alternative 1. Areas disturbed mine-related operations would be revegetated to stabilize soil and slopes, reestablish communities ecologically comparable to pre-mine conditions, and restore watershed, wildlife, recreational, and aesthetic values that meet post-operation land use objectives. However, no trees would be used in revegetation except on a limited basis for visual impact mitigation. Only grasses, forbs, and shrubs would be used to enhance wildlife habitat. Another change is that crested wheatgrass would not be used in the reclamation seed mix. Vegetative cover must achieve 90 percent of that demonstrated in adjacent, natural communities of similar composition and location to be considered acceptable. Stock grazing would be restricted in revegetated areas until the vegetation canopy is 90 percent or greater of the reference area and natural vegetative succession is established.

2.7.3 Monitoring Programs and Research Studies

Monitoring programs and research studies already in place or required under the Zortman and Landusky mines operating permits would not be substantively affected by this alternative. Implementation of the Water Quality Improvement Plan, designed to identify

degradation of water resources and trigger corrective action, should not substantively alter the basic water quality monitoring programs already required. A reclamation monitoring program would be instituted to provide ongoing evaluation of surface reclamation viability. Otherwise, the description of monitoring programs and research studies provided in Section 2.5.3 is applicable to this alternative. Potential changes or modifications to those programs are briefly presented in the following sections.

2.7.3.1 Water Resources

The monitoring program for groundwater and surface water would continue as described in Section 2.5.3.1. Some monitoring wells or surface water monitoring sites could be relocated as a result of actions taken to reduce heap leach facility slopes.

In addition, ZMI would be required to establish a monitoring program for operation and maintenance of land application disposal areas. This program, to be submitted to the agencies for review prior to land application of spent solutions, would include at a minimum the following elements:

- Analysis of barren solution samples prior to land application and during, to determine optimum hydrogen peroxide content and metals loading to soil
- Installation of suction lysimeters at varying depths with the land application area
- Collection of pore water samples (from lysimeters) and chemical analysis to include at least cyanide, arsenic, cadmium, copper, selenium, zinc, and lead
- Daily or more frequent monitoring of land application operations by mine personnel to check for runoff from the area, or new groundwater seeps
- Immediate sampling of all new seeps or discharges, or solutions found discharging from the area, and analysis for metals and cyanide

Should any discharges from the area be detected, in the form of solution runoff or new seeps, all land application procedures would be stopped. The agencies must be informed immediately of any such occurrence and approve corrective measures prior to re-start of land application.

In addition to complying with the monitoring requirements discussed in Section 2.5.3 and Appendix A, ZMI would be required to add the following wells and sites to the water resources monitoring program.

<u>North of the Zortman Pit Complex</u>

- A deep bedrock well near the S-1 drainage and Pink Eye Pearl adit, northwest of the Ross Pit
- A deep bedrock well above Glory Hole Gulch, near the old Badger Mine portal
- An alluvial/bedrock monitoring well pair on the north side of the confluence of Glory Hole Gulch and Lodgepole Creek

<u>South of the Zortman Pit Complex</u>

- Maintain or replace a bedrock monitoring well pair at the base of the removed Alder Gulch waste rock dump

<u>North/Northwest of the Landusky Pit Complex</u>

- A deep bedrock well in the Narrows Fault Zone above King Creek
- A deep bedrock well in the Suprise Shear Zone above Swift Gulch
- A deep bedrock groundwater well in the Gold Bug Shear Zone near the northeast corner of the Queen Rose Pit above Swift Gulch
- An alluvial/bedrock monitoring well pair in the upper reaches of King Creek near surface water monitoring station L-5

<u>Additional Surface Water Monitoring Stations</u>

- Lodgepole Creek about 1/4 mile below confluence with Ross Gulch
- Tributary to Montana Gulch from 83 pad area
- Mainstream Montana Gulch where it enters BLM campground
- South Bighorn Creek at the Reservation Boundary
- Swift Gulch just above the confluence with South Bighorn Creek
- Swift Gulch above Spring L-20, below Gold Bug Shear Zone

Monitoring Frequency

The frequency of monitoring would be increased so that all groundwater monitoring wells are sampled quarterly (four times per year) and the complete suite of water quality parameters (Table 2.5-18) analyzed each quarter. If a surface water monitoring station or groundwater monitoring well is found to be dry during several consecutive monitoring rounds, alternative flowing monitoring stations and/or water bearing monitoring wells should be installed in the immediate vicinity if at all possible.

2.7.3.2 Reclamation Surface Performance Study

Some expansion of the reclamation surface performance study would result from implementation of this alternative. ZMI would monitor seepage from waste rock facilities on a frequency sufficient to develop long-term hydrographs for each site. The hydrographs would be used to assess and predict how and when seepage responds to high flow seasons or storm events. The hydrographs would also provide a tool for predicting opportunistic sampling events to evaluate changes in seepage quality.

2.7.3.3 Surface Reclamation Monitoring Programs

ZMI would implement a program to monitor long-term viability of surface reclamation until such time as the agencies release the mine reclamation bond. The program must evaluate the continued performance of such features as:

- Reclamation covers
- Revegetation success and permanence
- Erosion control measures

The reclaimed facilities would be monitored for excessive erosion including rilling and gullying. Excessive erosion would be that level which endangers the overall efficacy of the reclamation features and could hinder the achievement of reclamation goals or environmental compliance requirements. Soil loss could not exceed 2 tons per acre per year. ZMI would be required to notify the agencies of such concerns with the reclamation systems, and propose and implement approved corrective measures to alleviate concerns.

ZMI would be required to submit a surface reclamation monitoring plan to the agencies for review and approval.

2.7.3.4 Other Monitoring Programs

No changes are anticipated to the remainder of the monitoring programs from the descriptions provided in Section 2.5.3.

2.7.4 Reasonably Foreseeable Future Actions

2.7.4.1 Mine Activities

Opportunities for future mining would be as described for Alternative 1 in Section 2.5.4.1. While this alternative does not preclude proposals for additional mining at either the Landusky or Zortman mines, none are foreseeable.

2.7.4.2 Mine Support Facilities

A permanent facility for storage or disposal of sludges produced by the water treatment plants is foreseeable. No major upgrades to access roads or electrical power service are foreseeable.

2.7.4.3 Exploration Activities

While this alternative does not preclude future proposals for exploration activities, none are anticipated. Since this alternative would not provide for the mining of already delineated ore reserves, the incentive to explore for additional reserves would be very low.

2.8 ALTERNATIVE 4: COMPANY PROPOSED MINE EXPANSIONS AND RECLAMATION

Alternative 4 is the proposal by ZMI for additional mining beyond that currently permitted at the Zortman and Landusky mines, and proposed revisions to the reclamation plans at each mine. Collectively, these activities are known as the Company Proposed Action (CPA). Figure 2.8-1 and Exhibits 1 and 2 display the existing facilities at each mine and the proposed new facilities.

A summary of the major actions proposed for the Zortman Mine includes lateral expansion and deepening of the pit complex to remove about 80 million tons of ore, construction and operation of a heap leach facility at Goslin Flats, construction and operation of an ore conveyor system through Alder Gulch to Goslin Flats, removal of the existing Alder Gulch waste rock dump, and construction of a new waste rock repository in Carter Gulch. ZMI would also implement enhanced reclamation practices for new facilities and those facilities already disturbed which may be creating acid drainage.

A summary of the major actions proposed for the Landusky Mine includes lateral expansion and deepening of the Queen Rose and August Pits, and mining in the South Gold Bug pit, to extract approximately 7.6 million additional tons of ore, expansion of the 87/91 leach pad by increasing the total pad capacity to approximately 19.5 million tons, development of a quarry in the King Creek drainage to obtain limestone for use in drains and reclamation systems, and construction of operational drainages to manage stormwater around leach pads, waste rock facilities, and the pit complex. ZMI would also implement enhanced reclamation practices for new facilities and those facilities already disturbed which may be creating acid drainage.

The proposed mine expansions are presented in Section 2.8.1, followed by the proposed reclamation plan modification for each mine as described in Section 2.8.2. Monitoring programs and research studies which ZMI would commit to undertaking for both mines are described in Section 2.8.3. Section 2.8.4 contains an assessment of other activities which are reasonably foreseeable should Alternative 4 be implemented.

2.8.1 Company Proposed Mine Expansions

__Zortman Mine__

The location of the Zortman Mine and the proposed expansion facilities are shown on Figure 2.8-1 and Exhibit 1, located in the map pocket of this document. The total disturbance for the Zortman expansion would increase to approximately 1,292 acres, which would include 405 acres previously disturbed under the existing permit and about 877 acres of proposed disturbance. Disturbance areas for the existing mine and proposed expansion facilities are summarized in Table 2.8-1.

ZMI would continue to use open-pit mining and heap-leach mineral processing to extract gold and silver from ore. Approximately half of the material proposed to be mined under the CPA would be low grade oxide ores, with the remainder consisting of higher grade, unoxidized material. The CPA would include mining up to a maximum of 80 million tons of ore and 60 million tons of waste rock. ZMI has projected production levels of 21 to 28 million tons of material per year, of which 12 to 17 million tons would be ore. Mining is proposed to proceed at these rates for approximately 5 to 8 years based on current economics and gold prices. A general flow sheet of the proposed process is shown on Figure 2.8-2.

The proposed expansion involves:

- Lateral expansion and deepening of the existing mine pit complex
- Construction of additional heap leach capacity at Goslin Flats
- Use of crushing for ore preparation
- Use of a conveyor for ore transport
- Installation of a solution pipeline along the conveyor route
- Development of a solution process plant, strip circuit, and refinery near the heap leach pad
- Removal of the existing Alder Gulch waste rock dump, for processing on the Goslin Flats heap leach pad

TABLE 2.8-1
DISTURBANCE FOR THE COMPANY PROPOSED ACTION - ZORTMAN

Facility	Proposed Total Disturbance[1] (acres)	Already Disturbed Area[2] (acres)	Proposed-Previously Undisturbed[3] (acres)
Mine Pits	200	97	52
Heap Leach Facilities	348	145	205
Waste Rock Storage	180.4	33.4	162
Roads	48.3	24.2	22.5
Conveyor Corridor	25	--	25
Processing Area	31.5	8.5	23
Coversoil Stockpile	50	15.5	48
Lime Quarry	10	--	10
Power Corridor	9	--	9
Land Application Area	350	65	285
Primary Ore Crushing	3.5	--	3.5
Ore Crushing/Handling	22	--	22
Storage Area	6.3	6.3	0
Shop	6.3	6.3	0
Wetlands (To Be Disturbed)	(0.97)	0	(0.97)
Replacement Wetlands	1.79	0	1.79
TOTAL DISTURBED ACREAGE	**1,292.1**	**401.2**	**868.8**
Seaford Clay Pit[4]	--	4.2	8.5

1 "Proposed Total Disturbance" refers to the total disturbance from the current and proposed operations.
2 "Already Disturbed Area" refers to the area disturbed under the current Operating Permit 00096.
3 "Proposed Previously Undisturbed" refers to currently undisturbed ground proposed for disturbance under this Amendment.
4 Seaford clay pit administered under an Open Cut Permit from DEQ and has not been included in the total disturbance acres.

NOTE: Proposed total disturbances (column 1) may not actually reflect the sum of the already disturbed area (column 2) and the proposed, previously undisturbed area (column 3). This is because some facilities may be constructed on areas already disturbed by other types of facilities. For example, about 97 acres of mine pits have been disturbed, and only 52 additional acres of previously undisturbed area would be added. However, the mine pits would also expand into areas currently disturbed by waste rock storage dumps and leach pads. Therefore, the proposed total disturbance is 200 acres.

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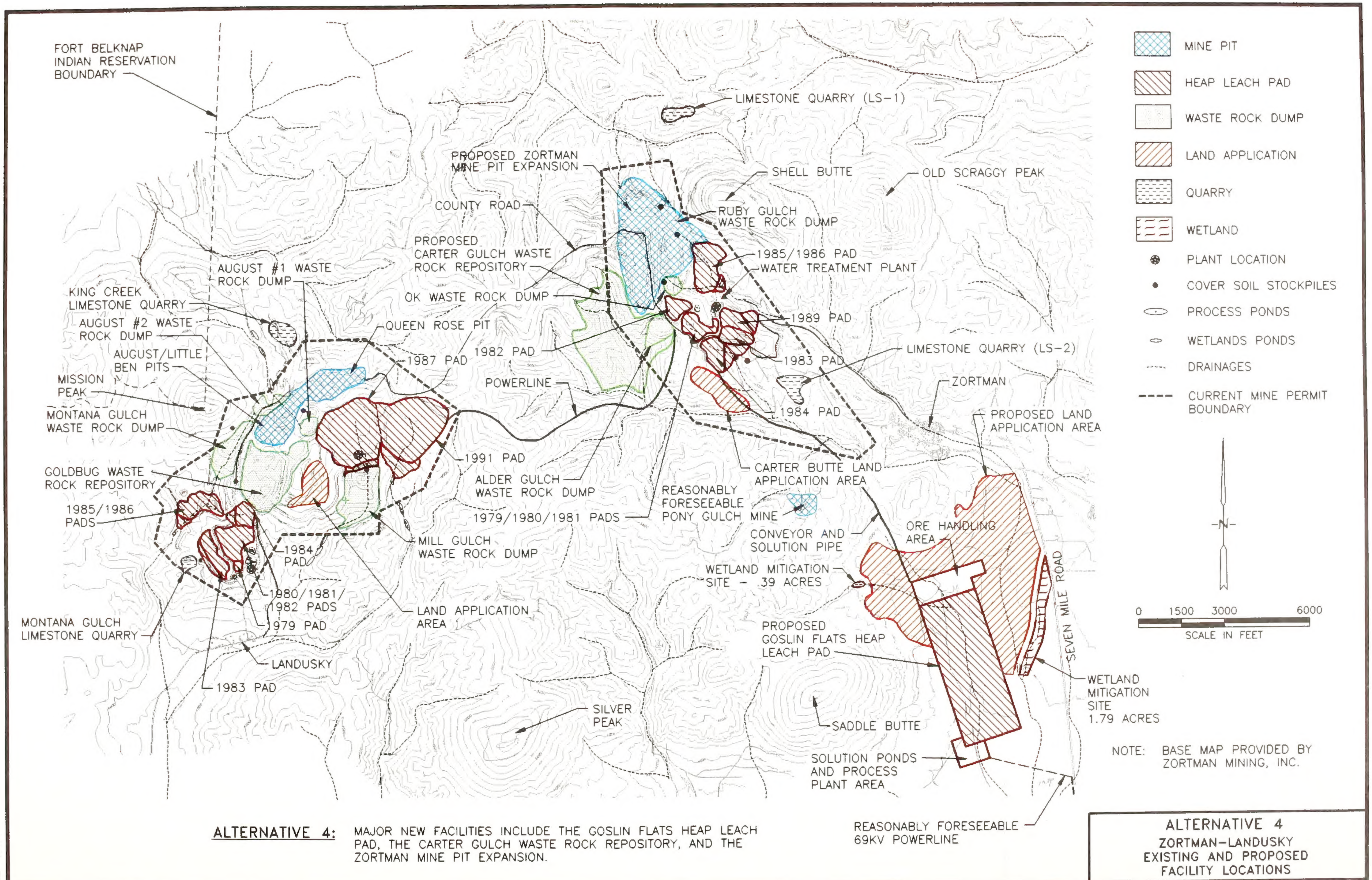
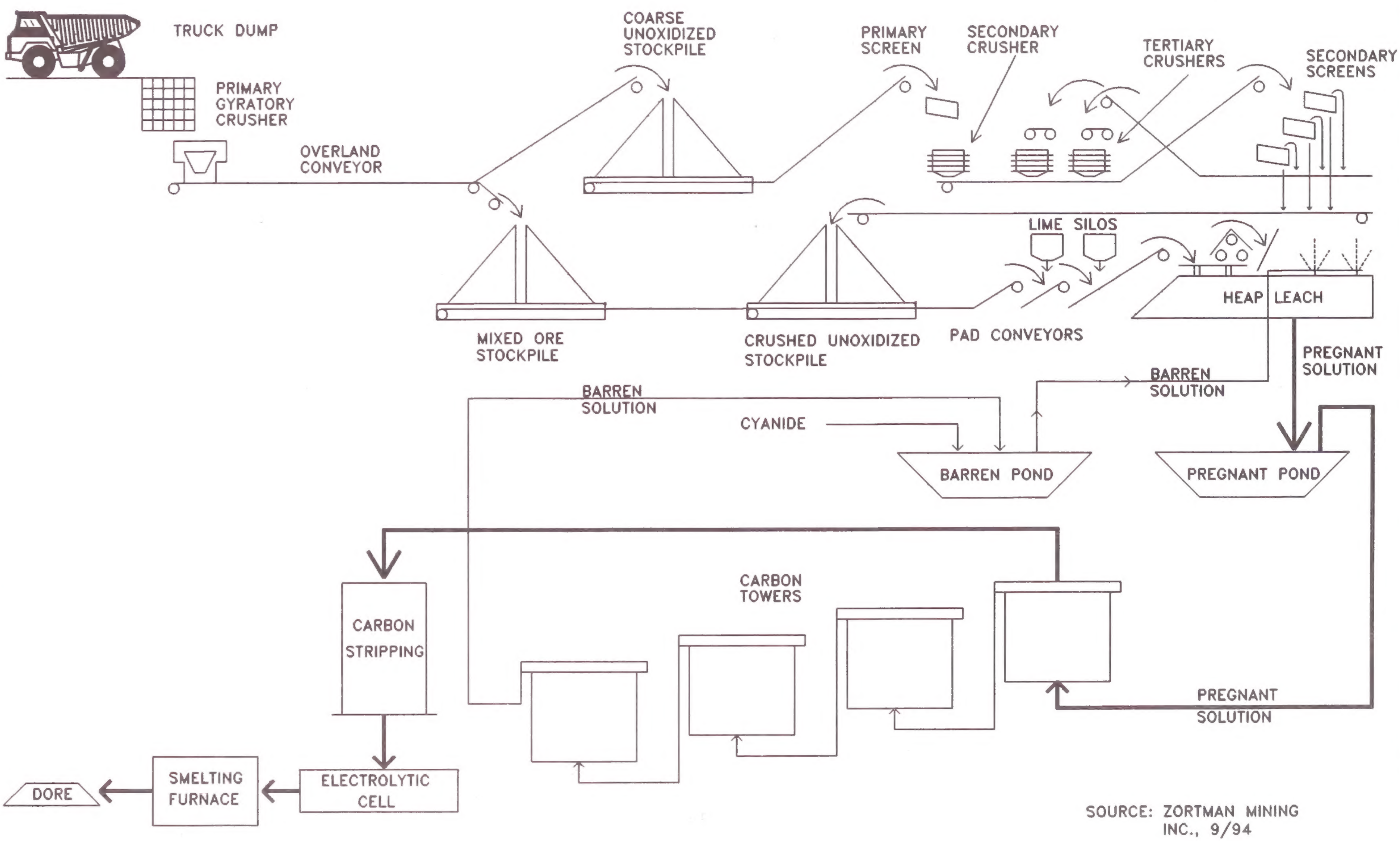


ALTERNATIVE 4: MAJOR NEW FACILITIES INCLUDE THE GOSLIN FLATS HEAP LEACH PAD, THE CARTER GULCH WASTE ROCK REPOSITORY, AND THE ZORTMAN MINE PIT EXPANSION.

ALTERNATIVE 4
ZORTMAN-LANDUSKY
EXISTING AND PROPOSED
FACILITY LOCATIONS

FIG. 2.8-1



FLOW CHART OF THE PROCESSING CIRCUIT

FIG. 2.8–2

173E0008

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- Removal of the existing Ruby Gulch sulfide stockpile for processing on the Goslin Flats heap leach pad

- Construction of a new waste rock repository in Carter Gulch

- Rerouting of the county road between Zortman and Landusky over Antoine Butte, construction of an underground power line between the Zortman and Landusky mines, upgrading of haul roads, and development of a new cover soil stockpile

- Expansion of the Seaford clay pit for bentonitic shale to be used for soil liner construction and various reclamation needs

- Development of a limestone source (LS-1), south of Green Mountain, for use during construction and reclamation

- An alternate water source for bats (or other wildlife) would be constructed in Goslin Gulch between Azure Cave and the leach pad site to mitigate potential loss of wildlife drinking water on Goslin Flats

The ore crushing and ore conveyance systems represent a change from the current processing operations at Zortman, where run-of-mine ore was transported to the leach pad by truck. Production is proposed at approximately 60,000 to 80,000 tons per day, with mining and leaching operations performed on a year-round basis. Table 2.8-2 summarizes currently permitted and disturbed acreages, proposed increases in disturbance area, and tons of ore and waste rock already mined and proposed to mine. The summary is based on currently approved ore and waste tonnages through Amendment No. 11 to the Zortman Mine Permit.

Mining and related operations would take place 7 days a week, 24 hours per day, 350 days per year. ZMI projects that the CPA work force would be similar to current operations, with approximately 260-280 full-time employees, depending on seasonal requirements. (This figure, however, is based on operation of only one mine since the Zortman and Landusky mines share a work force. If both mines are operating, approximately 360 to 380 full-time employees would be required.)

The material handling, crushing, overland conveyor, and heap stacking systems are designed to operate 24 hours per day, 7 days per week, 50 weeks per year. The solution, carbon adsorption, and carbon stripping system

TABLE 2.8-2
EXISTING AND PROPOSED DISTURBANCES - ZORTMAN

Description	Currently Permitted	Proposed Additional	Proposed Total
Permit Boundary (Acres)	961	4,794	5,755
Permitted Disturbance Area (Acres)	401	869	1,270
Total Ore (Tons)	20,200,000	80,000,000	100,200,000
Total Waste Rock (Tons)	7,800,000	60,000,000	67,800,000

and metals refinery are designed to operate 24 hours per day, 7 days per week, 52 weeks per year. The metals refinery is designed to operate 8 hours per day, 5 days per week, 52 weeks per year.

Landusky Mine

ZMI proposes several changes to current operations at the Landusky Mine, including provisions for mining an additional 7.6 million tons of ore and 7 million tons of waste rock. Service facilities to support the reclamation operations would include developing a limestone quarry and expanded shale pit excavations. The location of the currently permitted mine area and proposed expansion facilities is shown on Figure 2.8-1 and Exhibit 2, located in the map pocket of this document. The disturbances associated with these projects are shown on Table 2.8-3, below.

ZMI would continue to use open-pit mining and heap-leach mineral processing to extract gold and silver from ore. The quantity of ore to be mined under this application would constitute slightly less than one year of additional mining at the facility. No additional workers are anticipated to be hired under this expansion proposal.

2.8.1.1 Mine Pit Expansions

The CPA would involve lateral and vertical expansion of the open pit complex at the Zortman mine (the South Alabama, North Alabama, OK, Ruby, Ross, and Mint pits combined). Proposed mining would access ore and waste which are located both adjacent to and in deeper

TABLE 2.8-3
DISTURBANCES FOR THE COMPANY PROPOSED ACTION - LANDUSKY

Facility	Proposed Disturbance Increase[1]	Proposed Boundary Increase[1]
87/91 Leach Pad Expansion	0	0
Gold Bug Waste Rock Repository	0	0
LAD Support Area	14.0	0
Reclamation Access[2]	28.7	0
Drainage Construction	20.0	0
Quarry Areas and Access[2]	9.7	92.3
Total Disturbances	72.4	92.3

[1] All disturbances and increases in acres
[2] Access includes road disturbances

portions of the existing pit complex. In some areas, the outer edges of the pit would be extended up to 600 feet or more laterally. The pit would be deepened approximately 500 feet in some ore zones, to an elevation of about 4,500 feet. A plan view of the pit complex is shown on Figure 2.8-3. Typical cross-sections of the pit area are shown on Figures 2.8-4 and 2.8-5.

The CPA for the Landusky mine would involve lateral and vertical expansion of the existing Queen Rose/Suprise and August/Little Ben pits, and continued expansion of the South Gold Bug Pit. A plan view of the ultimate pit complex is shown on Figure 2.8-6. Typical cross sections of the expanded pit area are shown from two directions on Figures 2.8-7 and 2.8-8.

Mining Methods

Material is proposed to be mined from previously permitted and new pit areas. An overall 0.68:1 to 0.75:1 waste/ore stripping ratio is expected at the Zortman Mine. Mine operations associated with the expanded ore body would follow conventional open pit methods presently used. Ore would be mined via drill, blast and transport methods using haul trucks, loaders and shovels. Blasting would be accomplished using rotary drills with holes drilled on approximately 13' by 13' centers. A mixture of (ANFO) would be used as the main blasting agent.

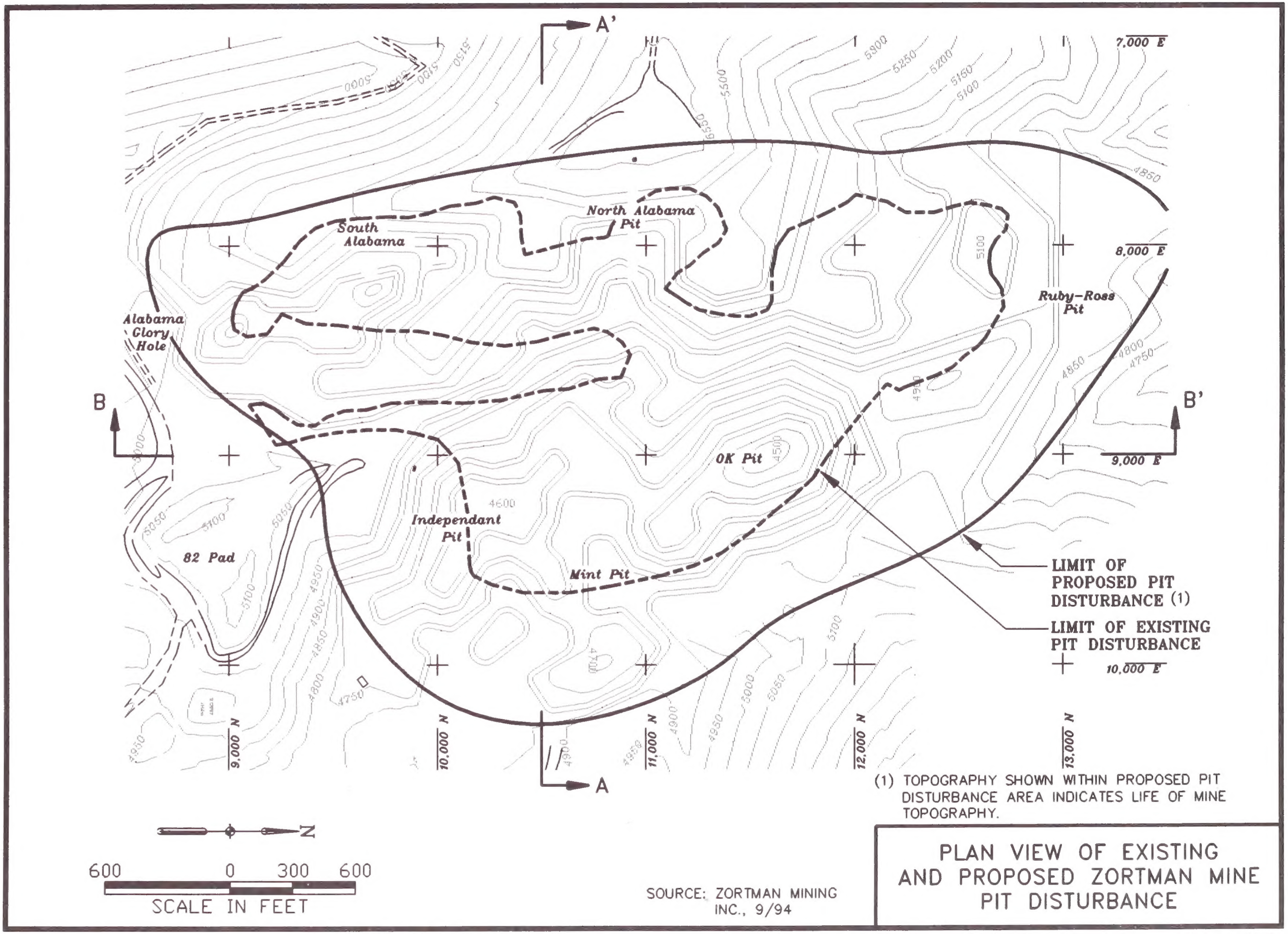
After blasting, oxidized ore would be loaded onto haul trucks and transported to a primary crusher, located at the crushing area near the pit. After an initial crushing, the ore would be transported via a conveyor system to a stockpile adjacent to the heap leach operation. Unoxidized ore would also pass through the primary crusher and be conveyed to a separate stockpile. The crushed unoxidized ore would pass through secondary and tertiary crushing in an enclosed facility near the leach pad (see Section 2.8.1.2).

At the Landusky Mine, ZMI proposes to mine an additional 7.6 million tons of ore and 7 million tons of waste rock from the Landusky operation beyond that which is currently permitted. No new lateral disturbance is associated with the Queen Rose/Suprise and August/Little Ben pits since expansion would occur within the existing pit outlines. Ore would be loaded by truck on the existing 87/91 leach pad. End of mine life, based on current permitted leach pad capacity for the 87/91 leach pad, is estimated to be early 1996. Permitting of the proposed 7.6 million ore tons would extend the mine life by approximately one year. Table 2.8-4 provides a summary of currently permitted and disturbed acreages, proposed increases in disturbance area, and tons of ore and waste both mined and proposed to be mined.

TABLE 2.8-4
EXISTING AND PROPOSED DISTURBANCES - LANDUSKY

Description	Currently Permitted	Proposed Additional	Proposed Total
Permit Boundary (Acres)	1,287	92	1,379
Permitted Disturbance Area (Acres)	814	73	887
Total Ore (Tons)	116,674,000	7,600,000	124,274,000
Total Waste Rock (Tons)	60,000,000	7,000,000	67,000,000

Mining would be conducted by ZMI using company personnel and a fleet of 12 to 16 Caterpillar 777B haul trucks (or similar equipment), 10 to 12 diesel powered support vehicles (bulldozers, loaders, road graders and shovels), and 25 to 40 gasoline and propane powered service and utility vehicles. Contractors could provide additional services that might increase totals in each of the above equipment categories by as much as 50 percent. Mine operations are scheduled for 24 hours per day, seven days per week. Total ore and waste rock mined per day would be approximately 60 to 80 thousands tons.



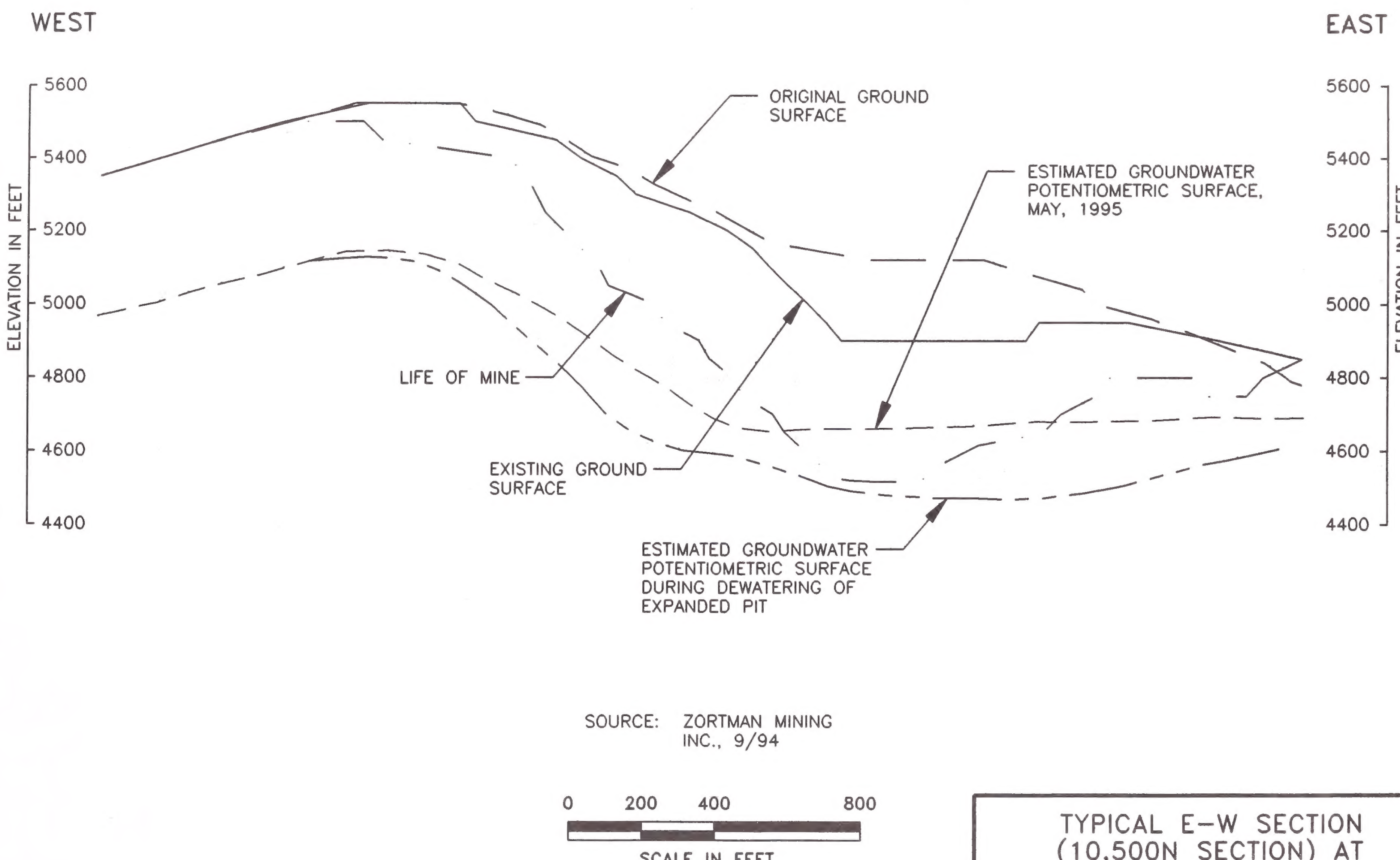
(1) TOPOGRAPHY SHOWN WITHIN PROPOSED PIT DISTURBANCE AREA INDICATES LIFE OF MINE TOPOGRAPHY.

SOURCE: ZORTMAN MINING INC., 9/94

PLAN VIEW OF EXISTING AND PROPOSED ZORTMAN MINE PIT DISTURBANCE

FIG. 2.8–3

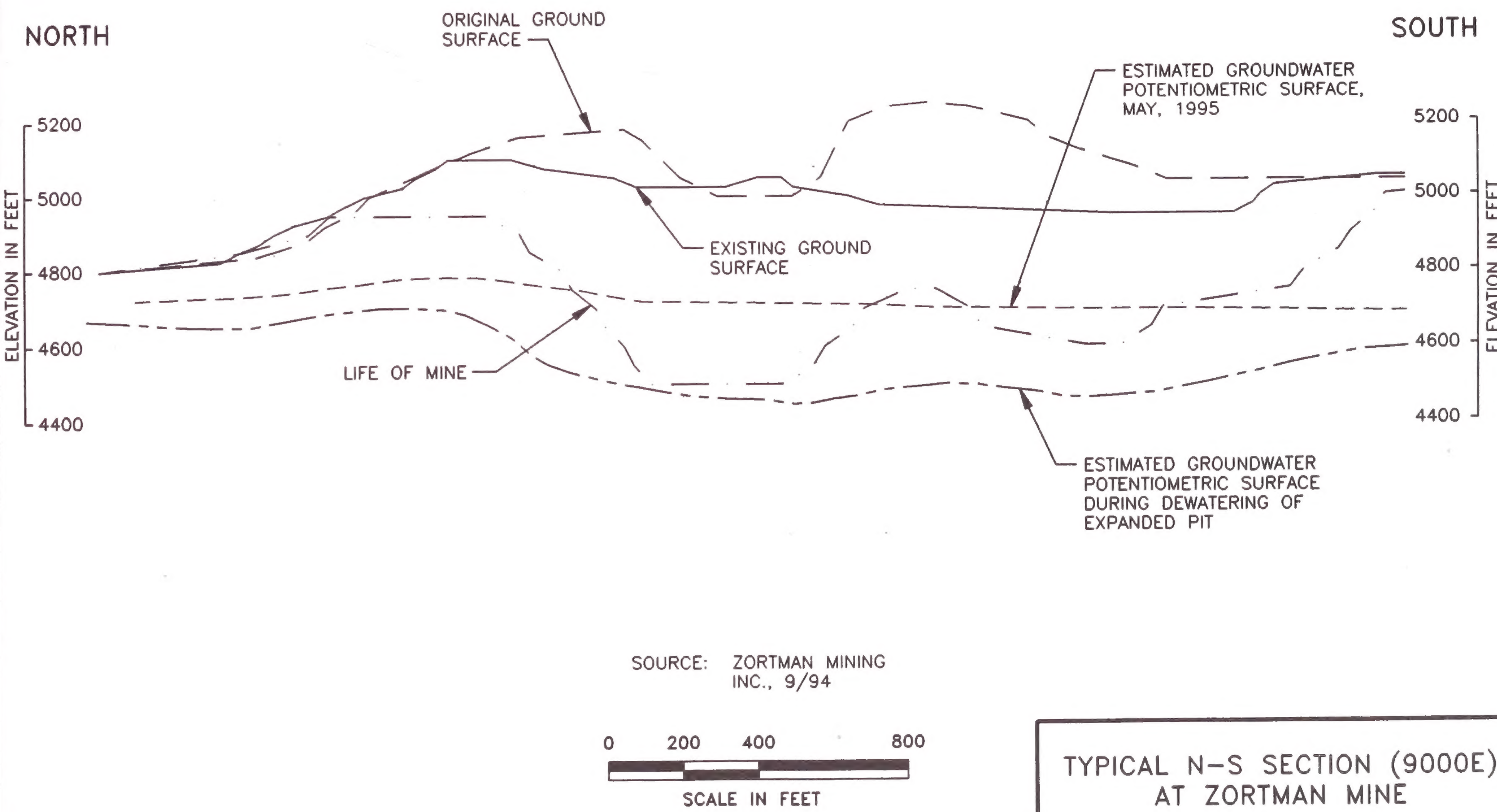
173E0010



TYPICAL E–W SECTION (10,500N SECTION) AT ZORTMAN MINE

173EZA-A

FIG. 2.8–4



SOURCE: ZORTMAN MINING INC., 9/94

TYPICAL N–S SECTION (9000E) AT ZORTMAN MINE

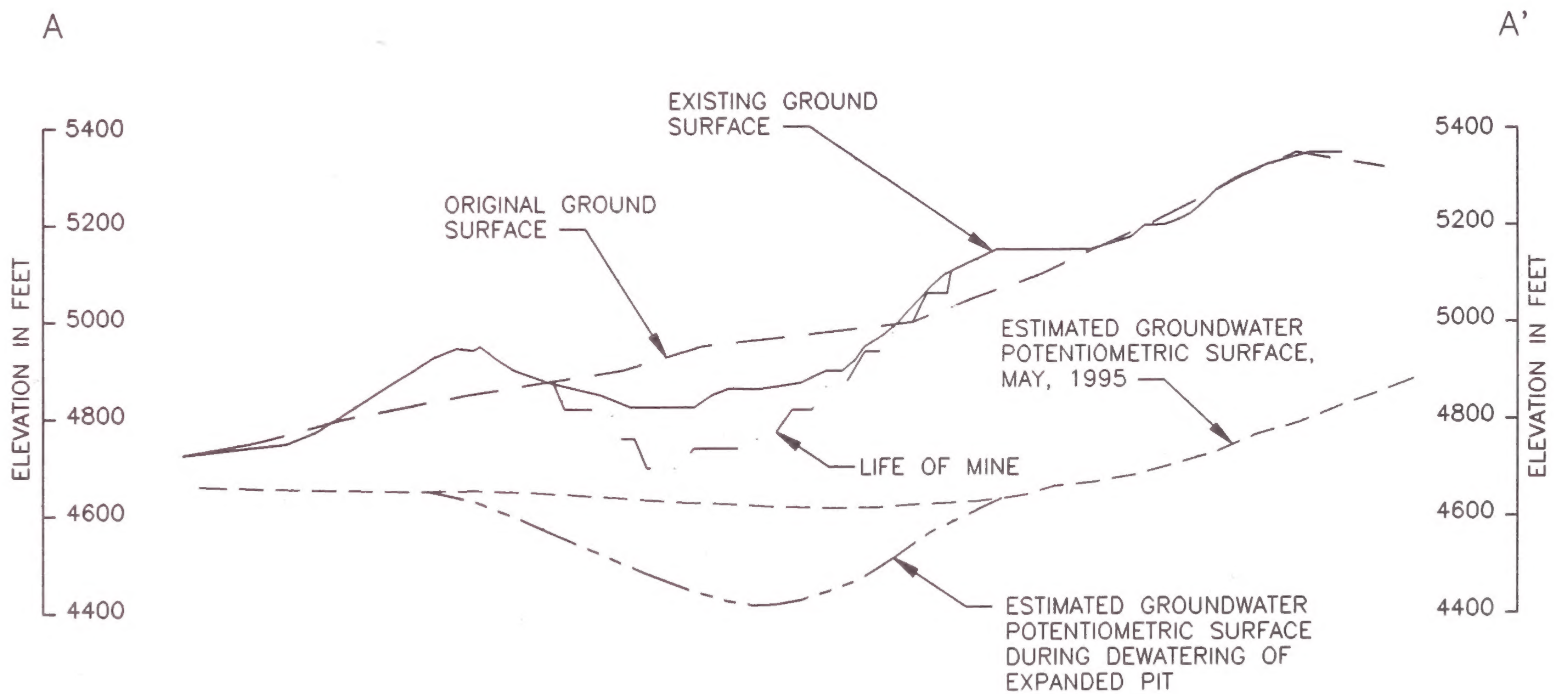
FIG. 2.8–5

173EZB-B

NOTE: TOPOGRAPHY SHOWN IN BOLD INDICATES LIFE OF MINE TOPOGRAPHY

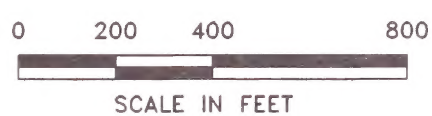
PLAN VIEW OF
PROPOSED LANDUSKY MINE
PIT DISTURBANCE

LANDDST1



SOURCE: ZORTMAN MINING INC., 9/94

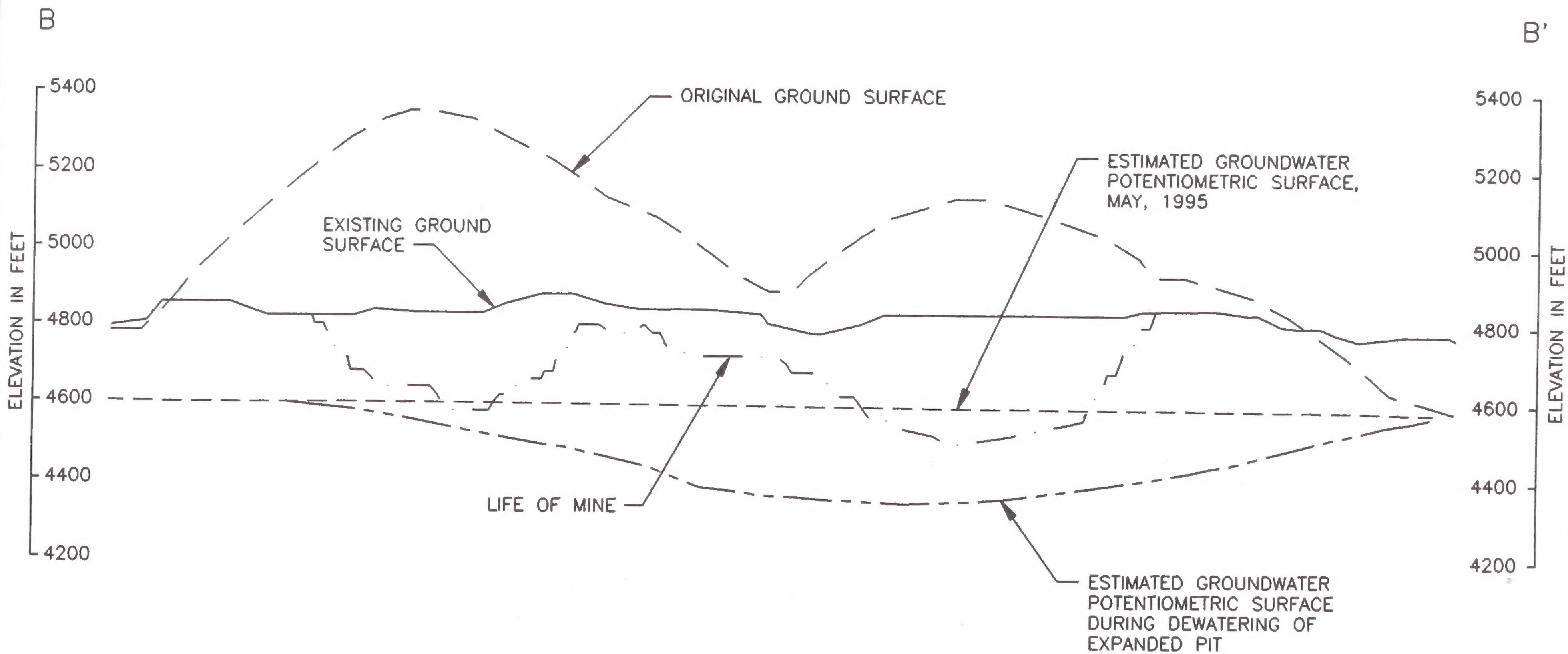
NOTE: SEE FIGURE 2.8-17 FOR CROSS-SECTION LOCATION



TYPICAL SECTION A–A'
LANDUSKY MINE

FIG. 2.8–7

173ELA-A



SOURCE: ZORTMAN MINING INC., 9/94

NOTE: SEE FIGURE 2.8-17 FOR CROSS-SECTION LOCATION

TYPICAL SECTION B-B'
AT LANDUSKY MINE

FIG 2.8-8

173ELB-B

Rock Characterization - Zortman Mine

The materials and their relative amounts to be mined during expanded operations are as follows. (See Section 3.1 for a description of the geology of the area, including descriptions of rock types and typical mineral associations.)

- **Tertiary Intrusives** - Tertiary syenite porphyries comprise the largest percentage of rock to be mined from the Zortman pit complex, at about 64 percent of the total rock volume. Quartz monzonite is another Tertiary intrusive, making up about 7 percent of the rock mined. The Tertiary intrusives would contribute approximately 70 percent of the ore processed, with the remainder classifying as waste rock.

- **Archaean Metamorphics** - Approximately 21 percent of the rock to be mined would consist of metamorphic rocks from the Archaean, primarily amphibolites (13 percent) and felsic gneisses (8 percent). Slightly more than half of this material would be suitable for ore processing, with the remainder classifying as waste rock.

In addition to the rock types listed above, minor amounts (2 percent) of quartzite, breccia, and Cambrian shale would be mined, with approximately one half of this material suitable as ore. The major rock types and their relative ore and waste percentages are presented in Table 2.8-5, below.

TABLE 2.8-5
ORE AND WASTE ROCK TYPES

Relative Age and Rock Type	Percent of Rock to be Mined	Percent Ore	Percent Waste
Tertiary: Syenite Porphyries	64%	35%	29%
Archaean: Amphibolites	13	6%	7%
Archaean: Felsic Gneisses	8%	6%	2%
Tertiary: Monzonite	7%	5%	2%
Quartzite, Breccia, & Cambrian Shale	2%	1%	1%
Unclassified	6%	4%	2%
Total	100%	57%	43%

ZMI has estimated that about 43 percent of the material removed during expanded mining operations would be classified as waste rock; in other words, the rock has insufficient content of gold or silver to be worth processing, and it would be placed in the waste rock repository. The presence of sulfide minerals in mining waste is of concern due to their potential to form ARD and for metals to be introduced to adjacent waters. However, the sulfide content is also important as it can be used to predict the potential of waste material to form ARD, and the ability to develop effective ARD source control measures is dependent on an accurate ARD prediction program. A geochemical sampling and testing program has been proposed by ZMI for the Zortman Mine expansion to minimize the risk of ARD from the proposed waste and heap leach facilities (see Figure 2.8-9).

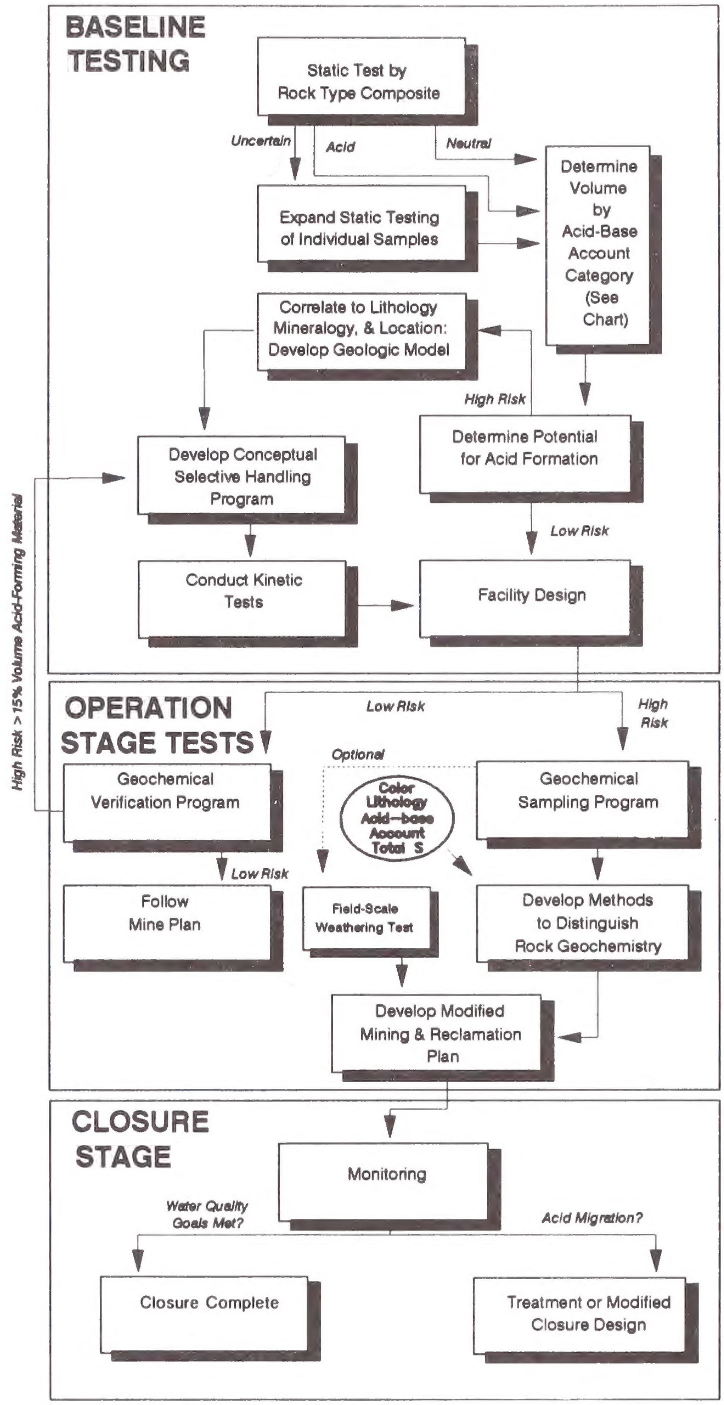
Geochemical sampling and testing of ore and waste materials was initiated prior to permit application submittal, and is on-going. These studies include Schafer and Associates (November 1992), and Schafer and Associates (June 1994).

Using results of the geochemical studies, ZMI has established a database that includes information on sample lithology, degree of weathering, color (and other readily observable field characteristics), and total sulfur content. The database is continually updated with additional sample information. The purpose of the database is for comparison of field characteristics to total sulfur values so that potentially acid forming and non-acid forming rocks can be readily identified in the field.

The geochemical sampling program would continue during mining to identify suitable (non-acid forming) and unsuitable (acid forming) waste rock. For the expansion project, a composite sample would be collected from every third drillhole (i.e., every 39 feet x 39 feet per 20 foot bench; about one sample per 1100 yd^3) and analyzed for total sulfur content.

Additionally, a split from approximately one in one hundred drill hole samples would be submitted for complete ABA analysis. Data from these tests would be used to correlate total sulfur values to ABA values. Other field parameters would also be correlated to ABA values when possible. Sample splits would also be submitted for complete acid base accounting analysis when material exhibiting unusual lithologic or mineralized characteristics is encountered.

A database has been established which contains the above described information. Since sulfur content may be estimated in the field (while ABA values can not), total sulfur contents have been established to correspond



SOURCE: ZORTMAN MINING INC., 9/94

GEOCHEMICAL EVALUATION FLOWCHART FOR PREDICTING THE ACID-FORMING POTENTIAL OF WASTE AND ORE FOR THE PROPOSED ZORTMAN PROJECT

FIG. 2.8-9

to ABA values which characterize non-acid forming (ABA typically greater than +20); acid forming (ABA typically less than -20); and uncertain waste types (ABA typically -20 to +20). The information developed in the rock characterization program would be used in determining how various waste rock types would be handled and segregated at the proposed waste rock repository in Carter Gulch, as described in the following section.

Rock Characterization - Landusky Mine

The materials and their relative amounts to be mined during operations at the Landusky Mine are as follows. (See Section 3.1 for a description of the geology of the area, including simplified descriptions of rock types and typical mineral associations.)

- **Tertiary Porphyries** - ZMI has estimated that 81 percent of the rock mined would consist of Tertiary felsic porphyries and associated breccias. Of this amount, approximately 38 percent would be taken to leach pads for processing and the remaining 43 percent would be scheduled for waste handling.

- **Paleozoic Sediments** - Approximately 13 percent of the rock to be mined would be from Paleozoic sedimentary formations, with less than 9 percent of this material containing sufficient amounts of precious metals to be worth processing as ore. The bulk of the Paleozoic rock is unmineralized Emerson Formation, consisting of limestones, marls, and calcareous shales which would all be handled as waste rock. These lithologies show less alteration, less mineralization and have lower sulfur content than the igneous rocks.

- **Archaean Metamorphics** - About 3 percent of the rock to be mined would be composed of approximately equal amounts of schists, gneisses and amphibolites. Archaean rocks have comprised a significant portion of the rocks mined at Landusky in recent time, but the proposed mining would result in removal of greater amounts of Tertiary and Paleozoic rocks.

The major rock types and their relative ore and waste percentages are presented in Table 2.8-6, below.

The program to characterize waste rock types according to their potential to generate acid or neutralize acid drainage, was described in Alternative 1, Section 2.5.1.4.

Waste Rock Handling - Zortman Mine

Waste rock would be hauled by truck to the Carter Gulch waste rock repository. Placement of the waste rock within the repository would be dependent on the

TABLE 2.8-6
ORE AND WASTE ROCK TYPES

Relative Age and Rock Type	Percent of Rock to be Mined[1]	Percent Ore	Percent Waste
Tertiary: Porphyries and Breccias	81%	38%	43%
Paleozoic: Sediments	13%	9%	4%
Archaean: Metamorphics	3%	2%	1%
Unclassified	4%	3%	1%
Total	101%	52%	49%

[1] **Total exceeds 100% due to rounding of percentages.**

material's potential to create acid drainage. Use of waste rock in facility construction and mine reclamation, and disposition of the waste rock, would depend on its sulfur content, as shown in Table 2.8-7.

TABLE 2.8-7
WASTE ROCK SEGREGATION AND ANTICIPATED VOLUMES

Category[1]	Total Sulfur[2] (%)	Waste Generated, In Tons and Percent
"Blue" Waste Rock (Non-Acid Forming)	0 - <0.2	7.43 million (12%)
"Yellow" Waste Rock (Uncertain Waste)	0.2 - 0.5	20.4 million (34%)
"Green" Waste Rock (Acid Forming)	>0.5	28.7 million (49%)

[1] A color coding scheme has been used to categorize waste rock for ease of identification and tracking
[2] Total sulfur would be assessed during materials testing as described below.

ZMI proposes a mine waste classification and selective handling plan based on total sulfur content. Non-acid forming, or "blue" waste, would contain less than 0.2 percent total sulfur and could be used in construction without restriction on the basis of geochemical properties. This waste would be stored alongside the waste rock repository. Uncertain, or "yellow" waste, would contain 0.2 to 0.5 percent total sulfur and would be used in construction over which an impermeable cover would be placed. This waste may be used in reclamation and would be stored around the margins of

the waste rock repository within the volume of waste to be protected by barriers. Acid forming, or "green" waste, would have greater than 0.5 percent total sulfur and would not be used in any construction. Green waste rock would be placed in the core of the waste rock repository.

Waste handling would rely on the following steps:

1. Any block which contains only blue waste blast holes would be scheduled as blue waste.

2. Any block which contains a mixture of blue waste and yellow waste blast holes would be considered yellow waste.

3. Any block which contains any green waste blast holes would be scheduled as green waste.

4. Any uncharacterized waste of uncertain character would be considered green waste.

Waste Rock Handling - Landusky Mine

Waste rock handling methods were described in Alternative 1, Section 2.5.1.1. A similar program for waste rock handling would continue at the Landusky Mine. This section describes how that characterization program would be used to sort and dispose each category of waste rock. The proposed waste rock repository expansion is also summarized.

Waste rock would continue to be segregated according to the criteria presented in the rock characterization section. Blue waste materials would be used in construction without restriction on the basis of geochemical properties. These materials would be stockpiled alongside the waste repository. Approximately 3 percent, or about 220,000 tons, of the waste generated during the expansion would be expected to classify as blue waste. Yellow waste materials would be positioned to ensure that their contact with air and water is limited. These materials would be placed around the margins of the waste repository, but within the volume to be protected by barriers. Yellow waste materials would also be used for constructions over which impermeable capping is planned. Approximately 13 percent, or about 855,000 tons, of the waste generated during the expansion is expected to be classified as yellow waste. Green waste materials would be placed in the cores of waste rock facilities which allow for isolation of the material. About 83 percent, approximately 5.8 million tons of waste rock, is expected to be considered green waste (Ryan 1994).

2.8.1.2 Crushing Operation

Metallurgical testing at the Zortman Mine has shown that unoxidized ore must be crushed to facilitate gold recovery. Crushing reduces the size of individual ore fragments, thereby increasing the surface area upon which the heap leach chemicals will act to separate gold from the rock matrix. Figure 2.8-2, shown earlier, illustrates the crushing systems and other processes used to move ore from the pit and prepare it for leaching. A brief description of the crushing procedure follows.

Ore would be hauled from the mine pit in trucks and placed in a truck dump hopper, located at the crushing area near the pit. In the event the hopper or conveyor system are inoperable, the ore would be placed in a stockpile adjacent to the primary crusher. Oxide ore would be crushed to less than 6 inches in diameter by a primary crusher, then conveyed to a mixed ore (both oxidized and unoxidized ore) stockpile located near the Goslin Flats leach pad. Unoxidized ore would also be processed through the primary crusher, and then pass through additional crushing mechanisms in an enclosed facility near the leach pad. The unoxidized ore requires additional crushing since it needs to be in smaller fragments than the oxide ore for the leaching process to extract gold and silver.

Unoxidized ore would be placed in a coarse ore stockpile near the leach pad and fed into the secondary and tertiary crushing mechanisms. These crushers would be located in two buildings connected by conveyors. The secondary and tertiary crushers would operate continuously with a pass-through rate of approximately 1,000 tons/hour, although up to 2,000 tons/hour could be processed if necessary. The crushed, unoxidized ore coming out of the tertiary crusher would be fed into either the mixed ore stockpile or placed in a third stockpile containing only crushed, unoxidized ore.

Therefore, three stockpiles would be developed near the Goslin Flats leach pad to hold ore. The mixed ore stockpile, with an 87,500-ton capacity, would contain approximately 70 percent oxide ore and up to 30 percent crushed unoxidized ore. The remaining crushed unoxidized ore would be placed in a second stockpile with a capacity of 19,400 tons. Both the mixed ore stockpile and the crushed unoxidized ore stockpile would be used to hold ore pending transport to the heap leach pad. The third stockpile, with a capacity of 68,100 tons, would be used to hold coarse (only crushed once in the primary crusher) unoxidized ore pending additional crushing. The crushing facilities and ore stockpiles by the leach pad would encompass about 22 acres of disturbance.

The truck dump, primary crusher, and ore stockpile area adjacent to the mine pit would be illuminated using mercury vapor or similar type bulbs directed downward from dusk to daylight, seven days per week. Six to eight lights fixed 15 to 40 feet above ground level would be required in this area. The ore stockpiles and secondary and tertiary crusher areas near the leach pad would be illuminated using mercury vapor or similar type bulbs directed downward from dusk to daylight, seven days per week. Five to eight lights fixed 15 to 40 feet above ground level would be required in this area.

Mining of the deeper portions of the Queen Rose/Suprise, August/Little Ben, or expanded South Gold Bug pits at the Landusky Mine would not require crushing or special handling for leaching purposes.

2.8.1.3 Conveyor System

An overland conveyor system would be used to connect Zortman Mine operations at the open pit complex with the heap leaching facilities at Goslin Flats. As illustrated on Figure 2.8-1, the conveyor would originate near the 84 leach pad, travel southeast through Alder Gulch, and enter Goslin Flats through the gap just west of Whitcomb Butte.

The overland conveyor would be about 12,000 feet long with an elevation drop of about 1,000 feet. The conveyor would, in most areas, be 5.5 feet from ground level to the top of the dust-control covers at the two transfer points, and have approximately 2 feet of clearance below the bottom belt. Six bridge sections are proposed that would have bridge heights ranging from 9 to 90 feet. Spans would range from 15 feet to 650 feet.

The conveyor belt would be approximately 42 inches wide with dust-control covers placed at the ore transfer points near the primary crusher and at the stockpiles near the secondary and tertiary crushers (the Air Quality Permit, in DEQ files, contains a description of proposed dust suppression measures on the conveyor and other mine facilities). The conveyor would travel at about 800 feet per minute with a design capacity of approximately 2,000 tons per hour. The conveyor would generate 1200 kV of power, which would be sent back into the local utility power grid. A roadway would be constructed along the conveyor route, where possible, for maintenance access. A 200-foot corridor with an average disturbance of 50 feet would be required for the conveyor and roadway.

The conveyor corridor would be fenced with four strand barbed-wire to limit public access. Security patrols of the corridor would further minimize public access to conveyor facilities. Public access to the southern range of the Little Rocky Mountains through Pony Gulch would be maintained. Due to the steep terrain involved on the route, fencing would not be possible the entire length of the conveyor.

Lighting would be provided by mercury vapor or similar type bulbs spaced every 15 feet, affixed 3 to 5 feet above the conveyor belt. The overland conveyor would be illuminated at two transfer points, one near the primary crusher by the mine and the other near the ore splitter adjacent to the ore stockpiles. Lighting would be provided by mercury vapor or similar type bulbs directed downward dusk to daylight, seven days per week. Two to four lights located 15 to 40 feet above ground would be required at each transfer point. Lighting would also be required from the mixed ore and crushed unoxidized feed conveyors to the stacker from dusk to daylight, seven days per week.

An emergency surge hopper would be placed at the end of the overland conveyor near the heap leach pad site. This hopper would be used to contain material discharged from the overland conveyor during any abnormal conveyor stoppage.

Transfer conveyors would feed material to the self propelled stacker on the heap leach pad. Lime for pH control and barren process solution for dust control would be added to the material on the transfer conveyors. Areas where barren process solution is added would be lined with drainage directed toward the pad or solution capture system. Blended ore would be stacked onto the leach pad in multiple lifts using the self propelled stacker operating on top of the heap. The heap stacking process would be repeated until the maximum capacity of the heap leach pad is reached.

Ore from the Landusky Mine would be transported by truck to the heap leach pad. No other ore conveyor system would be required.

2.8.1.4 Heap Leach Pads

Surface water diversions would direct natural flows away from the leaching facility toward the Ruby Creek drainage. The leach pad would be approximately 5,200 feet long by 1,800 feet wide and would be sized to contain 80 million tons of ore, the presently anticipated reserves. The heap leach pad liner design includes layers of compacted clay, a synthetic PVC membrane, and a crushed rock protective layer. Ore would be stacked in 25-foot lifts to a maximum depth of approximately 200 feet.

The Goslin Flats heap leach pad is designed as a modified flat leach pad (see Figure 2.8-11). Unlike conventional flat leach pads, the proposed pad would incorporate in-heap impoundment of solution to reduce pond costs and to aid cold weather operation. As shown on Figure 2.8-11, the leach pad design includes a composite liner and internal and external berms to contain and segregate the solutions. The perimeter berms would be approximately 5 feet high with approximate 2.5H:1V side slopes. Internal berms would be 4 feet high with 2.5H:1V slopes. Low dikes would also be constructed at the middle and lower end of the heap. The dikes would allow solution to collect in the heap. A surge capacity of about 30 million gallons of solution would be available as in-heap impoundment. An operational head (hydrologic pressure) of about 20 feet would be maintained on the liner at the dikes during normal operations. The system could handle a maximum of 40 feet of head.

The perimeter of the pad and process area would be fenced with 6-foot Page wire (similar to field fence, a 9 to 12 gauge woven wire). These fences would have 7.5-foot steel posts and 8-foot set posts, 6 inches in diameter. All posts would be placed 15' apart and the Page wire reaches 6 inches* high. The pad and process area perimeter, as well as the ponds within the perimeter, would be fenced to ensure wildlife protection. The ponds would also be netted to keep birds from landing on the ponds.

The Goslin Flats location would also be used to contain up to 1,000,000 yd^3 of cover soil salvaged during construction of the pad and plant facilities. The soil from leach pad construction would be stockpiled on approximately 48 acres next to the leach pad. This cover soil would later be used in reclamation activities.

Goslin Flats Leach Pad Construction

The following sections describe the construction and operation of the proposed heap leach pad at the Zortman Mine and how leaching solution would be processed.

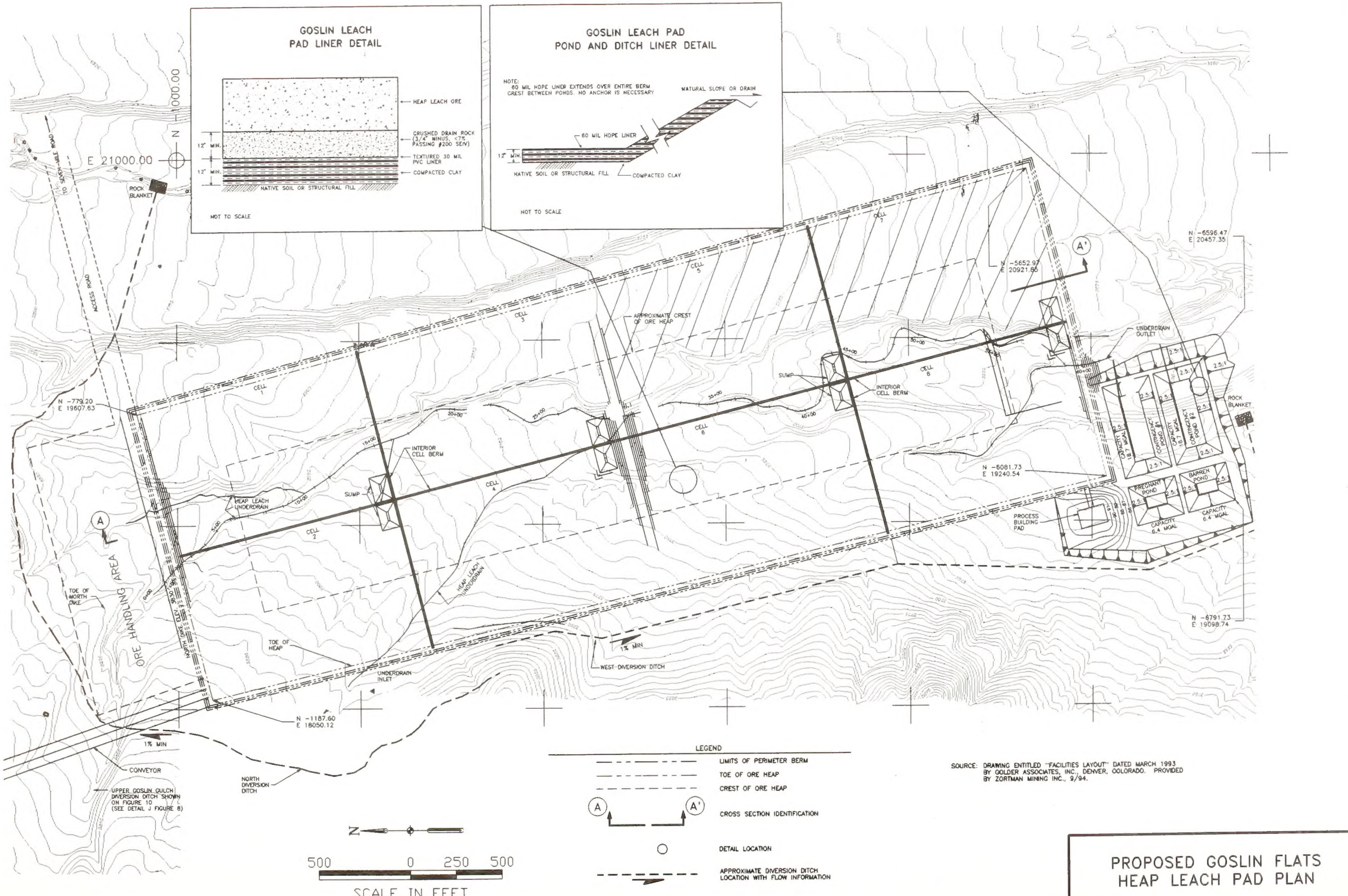
Foundation - Soil salvaged from Goslin Flats during construction of the heap leach pad would be picked up in two lifts and stockpiled separately, one for cover soil and the other for subsoil. The subsurface would be regraded to create a stable foundation surface and to ensure effective leach solution drainage from each cell to the retention pond. Materials considered unsuitable for the pad foundation, such as wet, frozen or soft soil, would be excavated and stockpiled. Structural fill would be required in some areas of the leach pad foundation to attain the desired grades; in other words, to make sure that the leach pad is sloped from north to south, so that solution would drain to the pregnant and contingency ponds. Subsurface testing of on-site alluvial/colluvium clayey silts, sands, and gravels has confirmed that they are suitable for use as structural fill (Golder Associates Inc. 1993). In addition, because much of the native soil and subsoil under the proposed leach pad area contains calcium carbonate, it would be used in construction or reclamation without restriction (see Section 2.8.2.1). Internal berms, sumps and external berms would be constructed using the compacted native material. Filter drains would be installed to prevent a buildup of groundwater beneath the leach pad that might affect liner stability and integrity. Structural fill would be placed in loose lifts of 8 inches and compacted to at least 95 percent of the Standard Proctor laboratory dry density, a standard unit of measurement employed to maintain quality control as construction progresses.

Dike and berm foundations would be prepared as described above. Interior bank and dike slopes would be no steeper than 2.5H:1V. Internal berms would maintain a minimum crest width of 10 feet, while the heap (outer) embankment would be at least 50 feet wide.

Liner - The leach pad liner system would consist of approximately 12 inches of compacted clay, mined from the Seaford clay pit, overlain by a textured, 30-mil PVC geomembrane. Approximately 347,000 yd^3, or 451,000 tons, of clay would be required for liner construction. The clay would be placed in 6-inch loose lifts and compacted to at least 95 percent of the Standard Proctor laboratory dry density. Liner detail is presented on Figure 2.8-11. Clay would be hauled approximately 5.5 miles from the Seaford pit to Goslin Flats using ZMI trucks or a contractor fleet. Clay hauled to the leach pad would not require transport through the Zortman townsite. Trucks would be grouped at the clay pit and travel as a convoy under the direction of front and rear pilot vehicles.

A minimum 12 inches of ¾ inch or smaller crushed rock would be placed on the PVC liner to protect it from potential punctures and tears during ore placement operations, and to provide an effective drainage horizon for solution transfer to the solution collection system. This material would consist of select, competent ore or waste rock which has been crushed and screened to less than ¾ inch size. No greater than 7 percent of the material would be silt or clay sized particles.

Ponds - The pregnant, barren, and two contingency ponds would be constructed by balanced cut and fill

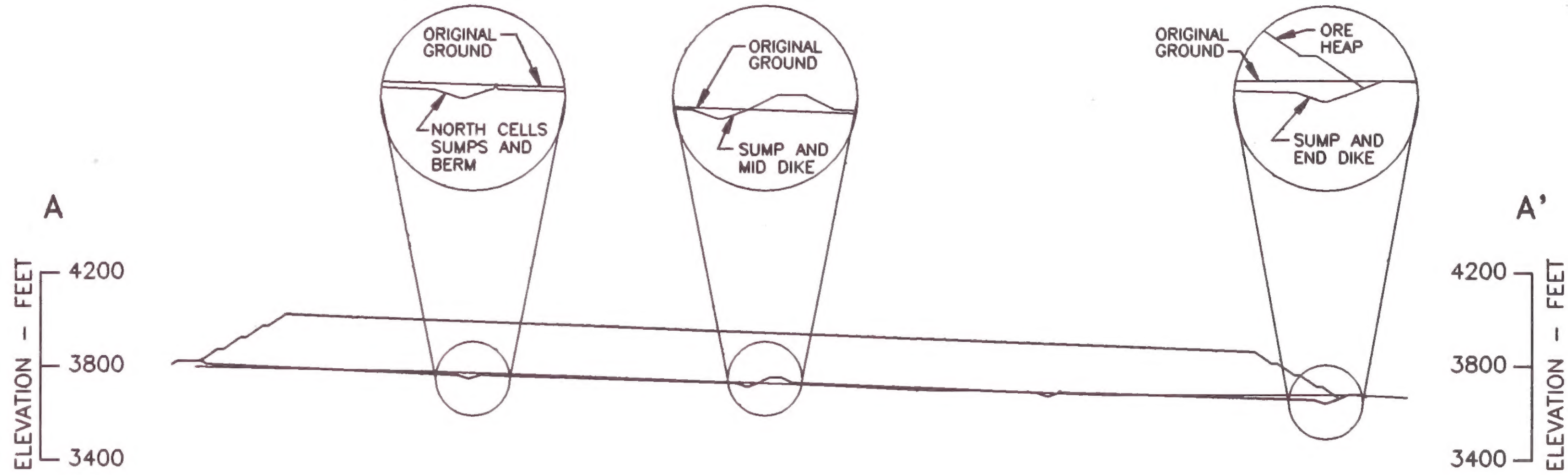


SOURCE: DRAWING ENTITLED "FACILITIES LAYOUT" DATED MARCH 1993 BY GOLDER ASSOCIATES, INC., DENVER, COLORADO. PROVIDED BY ZORTMAN MINING INC., 9/94.

PROPOSED GOSLIN FLATS HEAP LEACH PAD PLAN

173E0011

FIG. 2.8–10



CROSS SECTION A–A': SHOWS TYPICAL SECTION THROUGH PROPOSED GOSLIN FLATS HEAP LEACH PAD WITH DETAILS OF CELLS AND SUMPS TO PROVIDE IN–HEAP IMPOUNDMENT OF SOLUTION TO REDUCE POND COSTS AND AID IN COLD WEATHER OPERATION.

SOURCE: ZORTMAN MINING, INC. 11/94

GOSLIN FLATS
HEAP LEACH PAD
CROSS SECTION A–A'

173EGAA1

FIG. 2.8–11

methods. Interior and exterior side slopes would be 2.5H:1V. Underdrains would be installed to direct groundwater away from the ponds. Fill material would be placed and compacted in lifts and a 12-inch layer of compacted clay placed over the interior. A synthetic liner, consisting of 60-mil HDPE, would be placed over the clay. The pregnant and barren ponds would each hold approximately 6 million gallons of solution. The contingency ponds would be sized to hold the calculated leach pad runoff from a 24-hour, 6-inch precipitation event plus the 36-hour draindown of the leach pad in the event power was lost during the storm event. Therefore, each contingency pond would hold approximately 19 million gallons in storage. All solution ponds would be enclosed with 6-foot wire fencing and covered with netting to keep birds from landing on the ponds.

Birdnetting would be obtained from A&S Tribal Industries using their 1 5/8 inch by 1 5/8 inch ultraviolet protected PVC. The bird net system consists of 1/8-inch grid support cable weaved through the netting and anchored by 4-inch steel casing set in the ground and cemented in place. The bird netting weave points will be placed on 16 foot centers. Pond netting to be installed would be received in 17 foot widths. The netting material would be overlapped 6 inches on each side and laced together with 1/8-inch weave cable.

Construction Quality Control - Construction of the heap leach pad would begin on the northernmost section of the leach pad (the "upper end") and proceed southerly to the extent of the ultimate design. ZMI would retain a professional engineer or engineering company as an independent inspector to monitor leach pad construction. This inspector would be responsible for monitoring and reporting on all phases of construction to assure that design specifications are met, and that field modifications are justified and summarized. The inspector would perform or oversee material inspections and compaction tests, including compactions tests on structural fill material and the soil liner, permeability tests on the soil liner, strength tests of the soil liner, and grain size analysis of solution underdrain material. The inspector would also prepare daily reports. An as-built report and drawings of the facility would be submitted to the agencies for review.

An independent third-party engineering firm would monitor and oversee installation of the synthetic liner, including deployment of the liner to the site. Liner panels would have a minimum overlap of 6 inches and be welded together with an adhesive-bodied solvent on a clean seaming surface. All field seams would be tested using a 30 psi air lance along the entire seam. Where air pockets or riffles are observed, they would be marked, repaired, and air lanced again to ensure proper bonding. The entire liner area would be inspected. Wrinkles, punctures, or defects that may be detected would be repaired and tested in order to ensure proper bonding. Additionally, seam analysis samples would be collected and sent to a certified laboratory for peel adhesion and bonded seam strength (shear) to confirm field testing and observation. Quality control reports and drawings of the facility would be submitted to the agencies for review.

Goslin Flats Leach Pad Operation

Generally, facility operation at the Goslin Flats site would include: the leaching of ore stacked on the pad; collection of pregnant solution at the bottom of the heap in one of eight operating sumps; transfer of the pregnant solution to ponds for storage prior to metal extraction; the metal extraction process itself; and the storage of barren solution in a pond for re-application to the ore heap.

Leach solution would be sprayed onto the heap at an average application rate of 0.005 gal/min/sq ft (approximately ½ inch per hour). A system of pipes and valves would allow the solution that is retrieved from the collection sumps to be redistributed to the heap or sent to the process plant. Ore materials placed on the leach pad would vary from less than ½ inch to less than six inches in size. An oxide/un-oxide blend would be leached on the pad with lime added at a rate of approximately 4-8 lbs/ton of ore prior to loading. The mix of ore would typically be approximately 50 percent oxide/un-oxide, although there would be occasions where only oxide or only unoxidized ore would be loaded. Lime addition would increase pH values to enhance ore leaching.

The elevation of the bottom of the heap leach pad would be constrained by the requirement for gravity to control leach solution drainage to the pregnant and contingency ponds. Solution collection casings would be placed in the bottom of each of the internal collection sumps, and solution would be removed by pumps installed in the sumps. Pumps would transfer solution to the main lines where the solution would either be redistributed on another area of the heap or advanced to the pregnant pond. Solution from the heap that is of sufficient grade to send to the processing plant would be placed in a separate line to carry the solution to the pregnant pond. Solution exiting the process plant would flow to the barren pond before reapplication on the heap. Reagent quantities in the barren solution would be adjusted and the solution reapplied to the heap via the distribution header leading to the spray hubs.

87/91 Leach Pad Expansion

The 87/91 leach pad was developed by expanding the 87 leach pad to the east and the 91 leach pad to the west, for one combined unit. This leach pad has already been permitted and constructed. The 7.6 million tons of ore proposed to be mined under this expansion would be placed on the existing 87/91 leach pad. No new construction of either lined pad area or buttress is required or proposed; expansion of the pad would occur by increasing the vertical loading of ore on the pad. The final pad capacity on this facility would be increased from the current 101.9 million tons to 109.5 million tons, and the final elevation at completion would be 5,450 feet, an increase in elevation of approximately 50 feet. There are no changes in lateral disturbance which are associated with the increase in loading of this pad to 109.5 million tons.

Zortman Mine Solution Management

Figure 2.8-10 shows the location of the processing facilities, including the process plant and ponds to collect, store, and control processing solutions. No discharge of solution entering the processing facilities is proposed as part of the normal operations, other than that solution which enters the atmosphere as evaporate.

Solution at the Goslin Flats leach pad would be stored within the heap, in the pore space of the ore in the sumps and behind dikes, or in surface ponds. The volume of solution required for ore processing would be maintained by adding makeup water during periods of net solution deficit (i.e., dry months), and by temporarily storing solution during periods of net solution surplus (i.e., higher precipitation months). The average external makeup water rate is expected to be 140 gallons per minute.

Pond Capacity - The barren and pregnant solution ponds would be sized to store approximately one day's maximum anticipated process plant requirements plus one million gallons contingency. Based on a maximum process flow rate of 3,500 gallons per minute, the barren and pregnant ponds would be sized to retain approximately 6 million gallons each.

The total in-heap storage capacity is approximately 30 million gallons, with 14 million gallons impounded by the middle dike and 15 million gallons in the south dikes and their associated sumps. The contingency ponds have been sized to store a total of approximately 38 million gallons of solution. In total, the system (barren, pregnant and contingency ponds, and middle and south dike retention ponds) would have a solution storage capacity of approximately 80 million gallons.

Heap Draindown - Heap draindown is the process through which the moisture content of the ore at the time leaching is conducted is reduced to an amount which the ore can retain after leaching stops. This reduction in moisture content adds free solution to the system, thereby increasing storage requirements and reducing storage capacity. A certain amount of operational draindown occurs through the heap leaching process, as active leaching advances from one portion of the ore heap to another, thereby isolating some ore from the active leach cycle.

It is possible that a heap leach facility's solution pumps could become inoperable, thereby removing some or all of the ore being leached from the active leach cycle. In such instances, excess solution drains from the ore. This circumstance is known as emergency draindown. Should an emergency draindown occur during the design storm event (6-inch, 24-hour), excess solution would accumulate at the rate of approximately 1.4 million gallons per hour. ZMI has proposed a Goslin Flats leach pad design to accommodate a design storm and pump shutdown duration of 36 hours.

Solution Pipeline - A 10-inch steel, Schedule 40 grade B pipeline, double-lined with a 12-inch ADS pipe, would be constructed along the conveyor route. The pipeline would transport excess, weak cyanide solution of less than 25 mg/l WAD from the existing Zortman and Landusky mine facilities down to the Goslin Flats process plant where it can be used in the process circuit (see Figure 2.8-1 for pipeline route). Additional information concerning the use of weak cyanide solution can be found in Section 2.8.2.4.

The pipeline would be placed next to the conveyor line on the cut side of the maintenance roadway where underlying material is very competent. The double-lined pipe would follow the conveyor route on the roadway and over bridges, including the Alder Gulch crossing at a constant grade. Flow monitoring in the pipeline would be accomplished through the use of pressure or flow sensors that would automatically activate valve closures and pump shutdown, in the event pressure or flow fluctuated above or below a normal operating range due to leakage or rupture of the steel pipeline. The double-lined pipeline would convey leakage, if present, into the lined process ponds at Goslin Flats.

Landusky Mine Solution Management

No additional solution ponds are proposed in connection with the proposed additional ore and waste rock mining at the Landusky Mine.

Processing Plant Operations

At the Zortman Mine, a plant encompassing approximately 23 acres (including ponds) would be constructed at the southwest toe of the leach pad where solution from the pregnant pond would be processed to extract gold and silver. Five columns filled with activated carbon would collect the metals through an adsorption process, which means the metals would drop out of solution by fixing to the carbon particles. An average flow of 2,500 gpm of pregnant solution would pass through the columns, although the plant would be sized to handle up to 3,500 gpm. Pregnant solution would enter the first carbon column from the bottom, contact carbon as it proceeds upward, and overflow into a collection system where it would gravity-feed into the next column. Flow would continue in this way through all five columns, and exit the last column as barren solution. Eventually carbon in the first column would reach a maximum loading and the carbon would not be able to adsorb any more metals. When this occurs, the "loaded" carbon from the first column would be transferred to the carbon stripping circuit, described below.

Precious metals would be removed from each batch of loaded carbon in the stripping system. In this process, the temperature and pressure are elevated to about 210°F and 15 psi, respectively. A caustic solution is introduced into the carbon which strips the metal from the carbon. After gold and silver have been removed from the carbon, the solution would be pumped through an electrolytic cell. A current running through this cell transfers or "plates" the metals onto steel wool cathodes. The cathodes would then be sent to the refinery, mixed with a flux, and smelted in a furnace to produce dore. The dore would be stored until shipment to a commercial refinery for furthering purification.

ZMI expects to collect about four tons of "loaded" or metal-laden carbon per day of operation. The carbon can be reused after the metals have been stripped, but after repeated cycles impurities build up on the carbon which cannot be completely removed by acid washing and elution. These impurities reduce the ability of the carbon to adsorb metals. To regain this capacity, the carbon would be reactivated by heating in the presence of steam in a slightly oxidizing atmosphere. Wet carbon would be loaded into a rotary gas-fired reactivation kiln where it would be heated to about 1300°F. This process would oxidize organic impurities in the carbon and create new micro-pores to restore most of the adsorption capability.

The processing plant yard and pregnant, barren, and contingency pond areas would be illuminated using mercury vapor or similar type bulbs directed downward from dusk to daylight, seven days per week. Lighting would be spaced every 25 to 50 feet, 15 to 40 feet above the ground. Approximately 15 to 20 lights would be required in the process plant and pond area.

At the Landusky Mine, no change is proposed in operation of the processing plant. The existing facilities would continue to be used to process gold bearing solutions from the leach pads. There would be no changes in reagent handling and storage.

Leak Detection System

Underdrain seepage detection systems and shallow groundwater wells adjacent to the Goslin Flats leach pad would monitor for process solution leaks. No additional change is proposed to the leak detection system, as described in Section 2.5.1.3, Alternative 1. The existing underdrains and monitoring wells that are beneath and adjacent to the 87 and 91 leach pads would be used to monitor for process solution leakage.

Reagent Handling

Major reagents, including cyanide for leaching and lime for pH control, are proposed to be consumed at a rate of approximately 1 lb. and 4-8 lbs/ton of ore, respectively. Lime in the form of calcium oxide would be shipped at a rate of approximately 5 trucks per day, with an annual usage of approximately 36,000 tons per year. Lime would be stored in silos near the leach pad. Cyanide, in the form of sodium cyanide, would be brought in at a rate of one truck every other day with an annual usage of approximately 6,000 tons per year. Sodium cyanide used in ore leaching would be mixed in an agitation tank at the processing plant. Barrels of dry cyanide are also used in the carbon strip plant. The estimated annual use is approximately 82 tons per year.

Because cyanide is a potentially toxic compound, ZMI has prepared a contingency plan in the event of a cyanide spill at the Zortman or Landusky mines. This plan contains information on spill discovery, notification, containment, neutralization, cleanup and reporting (ZMI August 1991). Calcium hypochlorite would be used to neutralize spilled cyanide solution where the spill pH is greater than 10 and the cyanide concentration is less than 500 mg/l. If the pH is less than 10 or the cyanide is in a concentrated solution, lime would first be added to raise pH and dilute the concentration. Dry or highly concentrated cyanide solutions would never be treated with calcium hypochlorite due to the potential formation of cyanogen chloride (a toxic gas), and if water comes in contact with dry cyanide hydrogen cyanide gas could be released. Dry cyanide spills would be swept or shoveled into containers by cleanup personnel wearing suitable

protective equipment. The material could then be disposed into the barren pond. The ore processing facilities are designed to contain all spills within the buildings with a drain trench connected to the process ponds. The ore processing building would have a containment curb sized to hold at least the solution capacity of the carbon columns and holding tanks.

More information on the use of chemicals in mining and ore processing operations is found in Sections 2.8.1.8 and 3.14, Hazardous Materials.

2.8.1.5 Waste Rock Repositories

Zortman Mine

Prior to construction of the new Carter Gulch waste rock repository, ZMI would remove all of the waste rock, approximately 3.4 million tons, from the existing Alder Gulch Waste Rock Dump. The existing material in Alder Gulch is seeping poor quality water from the toe of the dump, and removal of the material would reduce impacts to the drainage. This material would be relocated to the leach pad at Goslin Flats for further processing as ore.

The proposed new waste rock repository would be constructed in Carter Gulch, a fairly steep side drainage to Alder Gulch (see Figure 2.8-1). Approximately 162 additional acres would be needed to store the waste rock generated by the CPA. The waste rock repository would be designed to hold 78 million tons, although ZMI's proposed action would generate approximately 60 million tons. The additional repository capacity is proposed for two reasons. First, the amount of waste rock generated could be greater than anticipated due to the variations in the stripping ratio. In addition, some potential exists for mining beyond that proposed in this action, and additional waste rock storage could be required under this reasonably foreseeable development (see Section 2.8.4).

Carter Gulch Waste Rock Repository Construction - Construction of the Zortman Mine waste rock repository would begin at the design toe. The first lift of waste would be end-dumped approximately 125 feet in height to compensate for the limited access to the toe area. Following completion of this lift, successive 25-foot lifts (see Figure 2.8-12) of waste rock would be placed on a one percent grade and backsloped so that surface water can be diverted away from the face of the waste rock storage area. Temporary diversion channels would be constructed as necessary to further reduce the volume of water coming in contact with waste rock during construction.

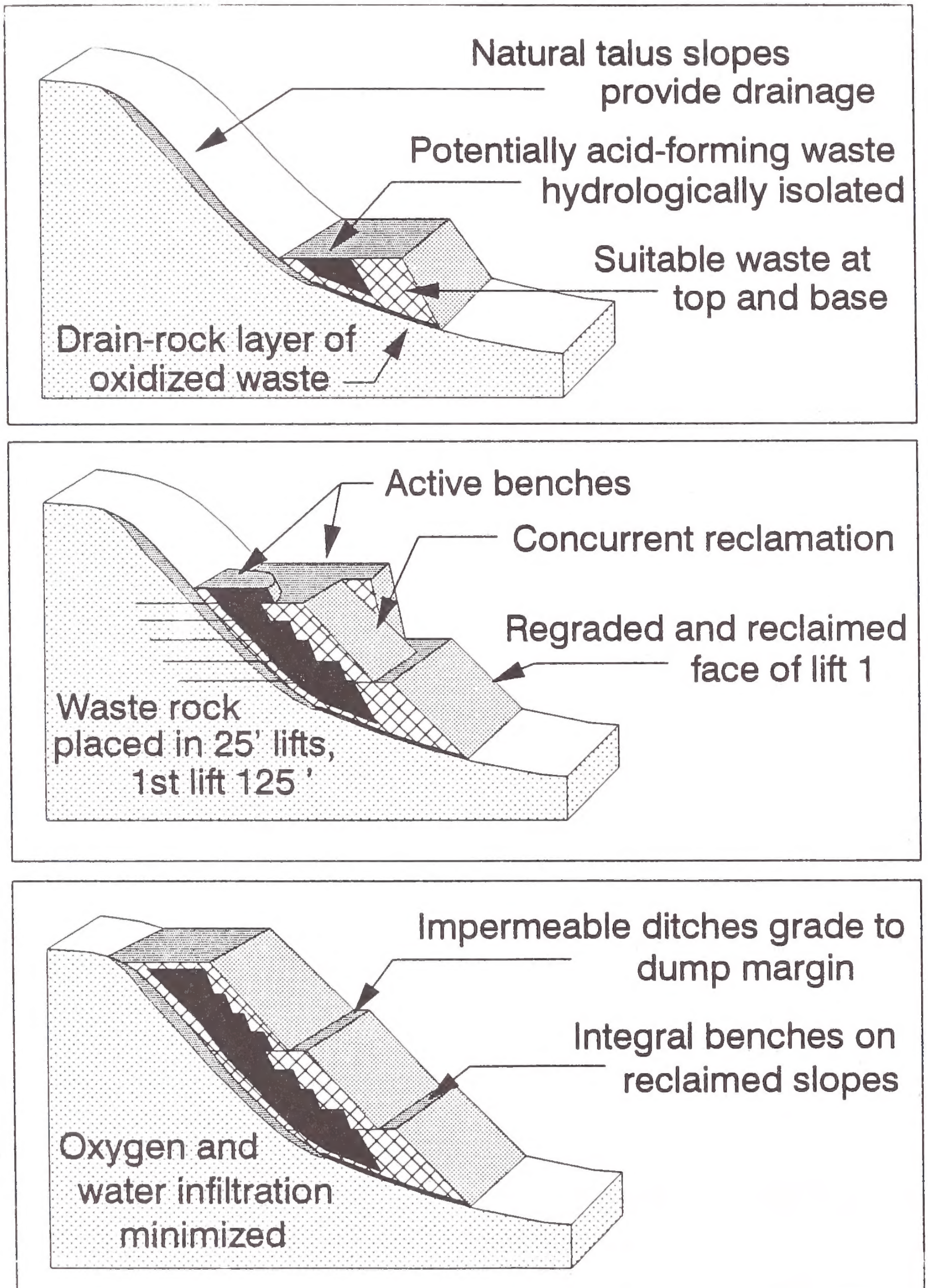
Waste rock would be managed according to its potential to generate ARD. Material with the least potential for ARD would be placed in contact with the valley floor and scree slopes. Acid forming material (as determined by the in-pit geochemical characterization program) would be isolated within the center of the repository.

ZMI proposes to use the natural scree slopes at depths of 5 feet or more to allow for natural drainage beneath the waste rock. In areas where scree depths are insufficient, mainly in the valley floor, rock/finger drains would be constructed out of selected coarse oxide material designated as non-acid forming by the materials handling plan. Every 100 vertical feet (4 lifts) the face of the waste rock storage area would be regraded to 3H:1V from the 4,800-foot elevation to the 5,100-foot elevation. This would include a 20-foot bench every 100 vertical feet with a slope angle between benches of 2.75H:1V. The slope below the 4,800-foot elevation would remain at an overall slope of 2H:1V. Reclamation covers would be placed on all regraded areas. Depending upon the time of year, vegetation would also be planted. For every 100 feet vertical, a 20-foot bench/access road would be left to allow for drainage and energy dissipation of surface flow. The bench would be backsloped and would drain laterally towards the waste rock storage area margin at 1 percent grade using a low-permeability drainage ditch constructed to convey surface water while minimizing infiltration. The completed waste rock face would have an overall slope of approximately 2.20:1. Additional information concerning reclamation of the waste rock repository is found in Section 2.8.2.5.

The completed first lift of the reclaimed waste rock facility would be monitored to evaluate the field performance of the proposed waste handling and facility design approach. See Section 2.8.3 for additional information on ZMI's proposed field performance monitoring program.

Landusky Mine

Seven million additional tons of waste rock would be mined and scheduled for disposal in the Gold Bug and Queen Rose Waste Repositories. Approximately 3 million additional tons of waste would be placed in the Gold Bug repository, and 4 million tons of waste would be backfilled in the Queen Rose pit. Waste rock from the expansion would increase the Gold Bug repository load to approximately 21 million tons. This amount of waste rock would fit within the repository's design capacity of 24 million tons. As in previous construction, the nominal slope of the repository would be built at 3H:1V, and drainage benches (15 to 30 feet wide) would be placed every 100 vertical feet. Reclamation at the



SOURCE: ZORTMAN MINING INC., 9/94

TYPICAL CONCEPTUAL CROSS-SECTIONS OF THE PROPOSED ZORTMAN PROJECT WASTE REPOSITORY AREA

FIG. 2.8-12

Gold Bug would continue to occur concurrent with mining activities. Section 2.8.2.4 provides more information on the repository reclamation program.

2.8.1.6 Other Features and Facilities

Office/Laboratory Facilities

The main office building for ZMI is located in the town of Zortman. The production assay lab is located across the street from the main office in a separate building. The laboratory and office functions would continue as described in Alternative 1, Section 2.5.1.5.

Access and Haul Roads

A road network map was presented on Figure 2.5-2, showing access and haul roads that would be active during the mining operation. A brief description of roadways follows.

Access Roads - The Zortman to Landusky road would be re-routed due to the expansion of the mine pit. Access road grades are designed to be 10 percent or less. Access road construction techniques for the proposed leach pad would be the same as access roads in the presently permitted areas. Access roads would be constructed using balanced cut-and-fill methods and are proposed to be approximately 30 to 50-feet wide where needed. Road beds would be compacted with construction equipment and topped with coarse gravel or fine oxide waste material. All roads would be sloped to allow for drainage away from the pad and waste rock storage areas. Drainage would be provided by sloping the roads as they are constructed so the drain ditches would handle runoff. Also, a berm would be placed on the outside edge of the road. Access roads would not cross any major drainages so culverts are not expected to be necessary. In the event that it becomes necessary, ZMI would install the required culverts to prevent erosion and channeling problems.

All access roads would be maintained as required for traffic, with road graders used as the primary maintenance equipment. All roads would be maintained throughout the life-of-mine.

Haul Roads - At the Zortman Mine, haul roads would be constructed to allow a 70-foot running width from the inside edge to the inside toe of the safety berm. All haul roads would be constructed on the daylight edge of the pit, which is the lowest area on the pit perimeter. Haul roads would be left on the remaining daylight edge after the pit is mined. One new haul road leading from the pit to the limestone quarry is proposed to be constructed outside of the pit boundaries. The limestone quarry haul road would have a running width of 50 feet.

At the Landusky Mine, a haul road would be constructed in the permitted disturbance area for accessing the South Gold Bug Pit area. Existing access and haul roads would be used and new roads may be constructed on existing disturbed areas within the pits. The 2,500 feet of haul road to the King Creek limestone quarry would be widened from 20 to 60 feet, resulting in an additional total disturbance of 5.7 acres.

Power and Water Supply

Power for the expanded operations at the Zortman and Landusky mines would be provided from the existing Big Flat Electric Cooperative lines into Zortman and Landusky. At the Zortman Mine, power requirements for the mine expansion and ore processing facilities would be supplemented by connecting the power supply at the Landusky Mine with the Zortman Mine. This would allow for any additional power needed at one operation to be allocated from the other. The powerline would be buried and follow the approximate route shown in Figure 2.8-1. An overhead power line would be erected adjacent to the access road connecting the county road with the ore handling area. An overhead power line would also be run from the county road to the process plant and pond area across Ruby Creek.

The ore and waste rock conveyor would generate up to 1,200 kW when running fully loaded. However, the primary source of power would come from the existing Big Flat Electric Cooperative power lines. This existing power system would provide sufficient power to start the conveyor motor while the Zortman and Landusky leaching and processing motors and equipment are operating, without overloading the line (ZMI 1995). The regenerated power from the overland conveyor would be used to start the primary, secondary, and tertiary crushing motors. Both the existing line power and regenerated power would be used to operate conveying, crushing, leaching, processing and ancillary facilities when all systems are operating.

The maximum power draw occurs when a motor is being started. A programmed logic circuit would be installed by ZMI so the overland conveyor motor and crushing motors cannot be started at the same time. In the even the secondary and tertiary crusher motors are operating while the conveyor is down, sufficient line power would be available to run them **(Source?)**. However, it would be necessary to shut down the secondary and tertiary crusher motors in order to start the primary crusher and overland conveyor, then restart

the secondary and tertiary crusher motors when regenerative power is available from the conveyor.

An average water supply of 190 gpm would be obtained from groundwater wells for the expansion. ZMI has an appropriation from the Department of Natural Resources and Conservation to obtain this makeup water, using supply wells ZL-102 and ZL-163 (see Exhibit 1). Peak water requirements from pumped groundwater are expected during winter months when less effective precipitation is received. Estimated average volume requirements for specific purposes include 140 gpm for ore-wetting and evaporative losses from the processing circuit, and 50 gpm for road dust control.

No changes are proposed in the current power and water supply systems for the Landusky Mine. Electrical power is obtained from the Landusky grid, which is supplied by the Big Flat Power Cooperative through an existing 23 kV line. Potable water is obtained from groundwater wells. Process water is obtained from precipitation and groundwater appropriation.

Sewage Treatment

At the Zortman Mine, an additional septic treatment facility with a drainfield would be placed at the Goslin Flats process plant. Six full-time employees are expected to work at the plant. A standard 1000-gallon, precast concrete, two compartment septic tank would be used. The drainfield would be designed to EPA standards. The septic system would be installed by licensed and certified contractors.

At the Landusky Mine, no changes are proposed from the current septic waste treatment systems. See Section 2.5.1.5, Alternative 1, for additional information.

2.8.1.7 Water Management

This section presents an overview of water management plans prepared by ZMI to mitigate impacts to water quality from existing and proposed expanded mining operations. It includes a description of measures that have been or would be implemented for management of process water, storm water and mine drainage. This section is divided into discussions on surface water runoff control, water capture, water treatment and LAD. The existing water management measures are described in Alternative 1, Section 2.5.1.6 and are not repeated in this section. Additional detail on measures to improve and maintain water quality are contained in the Water Quality Improvement Plan which is presented in Appendix A.

Objective: The objective under this and all alternatives is to protect beneficial use and to achieve and maintain compliance with water quality standards.

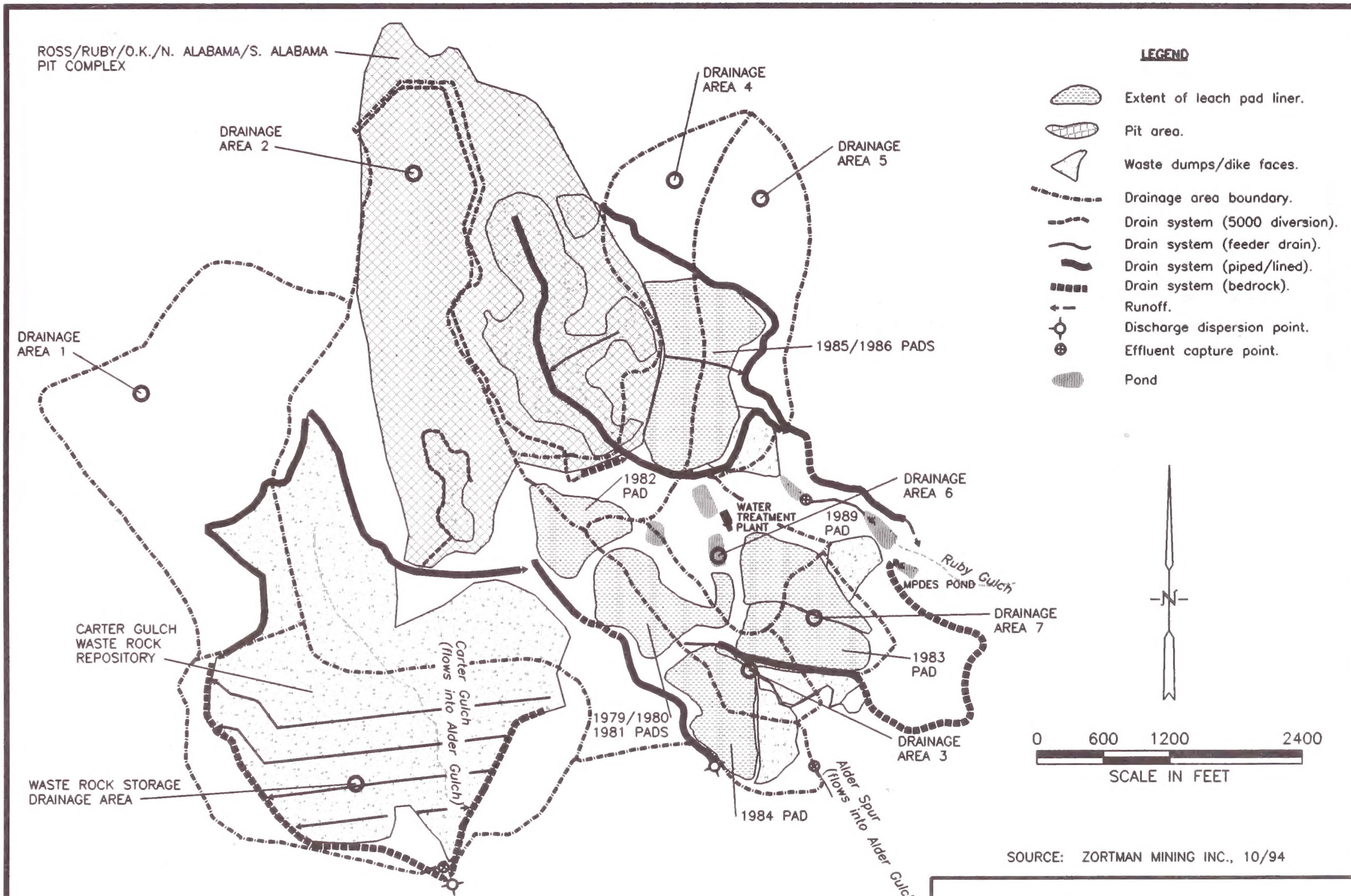
Approach: This alternative relies on a combination of source control and active water treatment to protect water quality. Mine waste is segregated and isolated based on acid generating potential. Improved reclamation covers and diversion of runon waters are used to limit water contact with potentially acid generating materials. Capture and treatment of impacted waters is required initially and used as a secondary measure in the long-term.

The emphasis is to institute source controls to prevent contact of surface or ground waters with potentially acid generating materials. Reclamation covers which would greatly reduce or perhaps eliminate the need for long-term water collection and treatment are required. The management of mine water requires keeping mine drainage, storm water and process waters segregated so that each can be handled using the technology most appropriate to each waters character.The Zortman Mine Goslin Flats heap leach pad and adjacent facilities, shown on Figure 2.8-10, would cover approximately 250 acres situated in the Goslin Gulch drainage, a natural bowl created between Saddle Butte, Whitcomb Butte and the Ruby Creek drainage.

Surface Water Runoff Control

At the Zortman Mine, the surface runoff was modeled for each specific subdrainage affected by the project. The runoff model used is based on the SCS National Engineering Handbook, Section 4, Hydrology (NEH-4). The model results were used to determine diversion ditch design, location, and rip-rap size. Figures 2.8-13 and 2.8-14 show the location of subdrainage areas for the mine and leach pad sites, respectively. A 24-hour storm event producing 6.0 inches of precipitation (total) was selected as the design storm to be modeled through each subdrainage in the mine and leach pad areas. A storm simulating a Soil Conservation Service Type II thunderstorm event was used. Results of the modeling are presented in Table 2.8-8.

Surface runoff during operations would be controlled with constructed drainage diversion channels. Runoff would enter constructed channels and be directed to settling basins, natural drainages, or rock underdrains. Several sizes of diversion channels are proposed for flows ranging from 27 to 408 cubic feet per second. The design includes maintenance of a minimum 12-inch freeboard during anticipated peak channel flow to accommodate any increased precipitation during operations.



SOURCE: ZORTMAN MINING INC., 10/94

ZORTMAN MINE DRAINAGE PLAN: INDICATES SURFACE WATER CONTROL FEATURES AND LOCATIONS OF MINE SUBDRAINAGE AREAS WHICH CONTRIBUTE TO THESE CONTROL FEATURES

ZORTMAN MINE
DRAINAGE PLAN

FIG. 2.8-13

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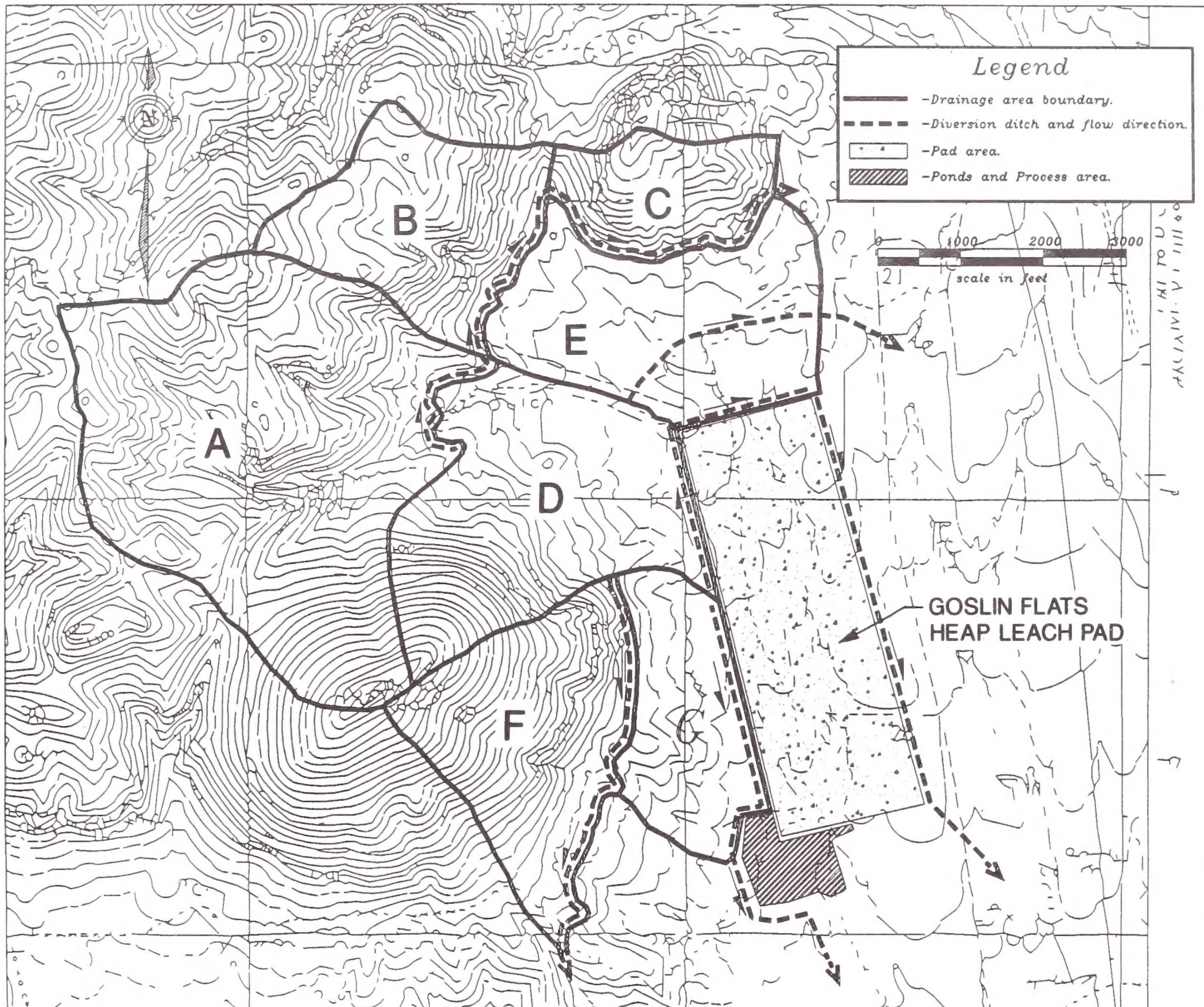


CATCHMENT BASINS:

INDICATES SURFACE WATER CONTROL FEATURES AND CATCHMENT AREAS FOR PROPOSED GOSLIN FLATS HEAP LEACH PAD SITE

SOURCE: ZMI AMENDMENT TO OPERATING PERMIT 00096 DATED 4/5/93.

CATCHMENT BASINS FOR THE GOLSIN FLATS HEAP LEACH PAD SITE

FIG. 2.8-14

TABLE 2.8-8
MODEL OF 6-INCH, 24-HOUR PRECIPITATION EVENT

Mine Site[1] SubDrainage	Peak Flow (cfs)[2]	Pad Site[1] SubDrainage	Peak Flow (cfs)[2]
1	116	A	293
2	408	B	118
3	110	C	79
4	161	D	193
5	100	E	99
6	86	F	146
7	77	G	93
Waste Repository Benches	27		
Alabama	45		

[1] See Figures 2.8-10 and 2.8-11 for a key to the numbered and lettered drainages.
[2] cubic feet per second

The proposed channel for drainage areas 1, 3, 4 and 5 is a trapezoid shaped section with a 4-foot bottom, 2H:1V sides and a maximum flow depth of 1.5 feet. The proposed channel for drainage area 2 is a trapezoidal channel with a 10-foot bottom, 2H:1V side slopes and a flow depth of 2.0 feet. The proposed channel for drainage areas 6 and 7 is a V-ditch with a channel depth of 3.25 feet and a flow depth of 2.0 feet. The proposed channels for the Goslin Flats leach pad area are trapezoidal channels with 12-foot bottoms, 2H:1V side slopes and a flow depth of 3.25 to 4.75 feet. The ditches would be lined with a geotextile fabric to prevent piping and covered with durable, non acid forming rock rip-rap ranging in size from 4 to 30 inches, dependent on the individual drainage area requirements.

All diversion ditches (except some above pit diversions) would have road access for maintenance. Maintenance would consist of removal of sediment load and repositioning of rip-rap as required. Sediment would be disposed in the waste rock repository.

Rip-rapped channels or existing scree slopes would be proposed for outfall structures. A rock blanket would be constructed at diversion discharge points in existing natural drainages. The rock blanket channel would consist of a geotextile lined diversion channel rip-rapped with 1.5 to 5.0 feet of durable, non acid forming rock. Scree slope outfalls would be used where discharge points occur above the existing natural drainage.

The pit, waste rock repository, primary crusher, and portions of the conveyor corridor are included in subdrainages for the "mine site." The mine site subdrainages collect runoff from an area of 0.86 square mile and have slopes ranging from 8.8 to 25.9 percent.

At the Landusky Mine, surface water runoff diversions and controls would be sized for a 6-inch, 24-hour storm event with freeboard added as a safety measure. Diversion channels would be trapezoidal or V shaped, lined with geotextile to prevent piping and rip-rapped with durable, non-acid forming rock sized for drainage area requirements. Figure 2.5-4, in Alternative 1, illustrates location of lined and bedrock diversion ditches and outfalls.

All diversion ditches would have road access for maintenance purposes. Maintenance would consist of removal of sediment load and repositioning of rip-rap as required. Sediment would be disposed of in the waste rock repository.

Rip-rapped channels or existing scree slopes would be used for outfall structures. A rock blanket would be constructed at diversion discharge points in existing natural drainages. The rock blanket channel would consist of a geotextile lined diversion channel rip-rapped with 1.5 to 5.0 feet of durable, non-acid forming rock. Scree slope outfalls would be used where discharge points occur above the existing natural drainage.

Zortman Mine Pits

The following diversions would be constructed for the expanded mining at the Zortman Mine.

Above-Pit Diversions - Berms and V-ditches would be used to direct storm water flow on the haul roads away from the pit, where possible. Berms and V-ditches would be constructed above pits where possible to prevent storm water runon.

5,000-Foot Diversion - A diversion would be constructed during operations at approximately the 5,000-foot elevation to reduce the amount of storm water runoff into the mine pit below this level. The "5,000 diversion" would begin at the north side of the pit area, near the Ruby-Ross pit, with a beginning elevation of 5,060 feet. The diversion would be constructed with a 2 percent gradient and would direct flow southward where it would combine with flows from the waste rock repository and Alabama pit areas. The bottom of the diversion elevation would be approximately 4,990 feet

near this confluence. From here, the diversion would route flow to the southeast until it enters a diversion basin, and ultimately, Alder Gulch. The 5,000 diversion, above the confluence with the Alabama Pit and waste rock repository contributions, would be sized to handle runoff from a 6-inch, 24-hour design storm [(a maximum of 201 cubic feet per second (cfs)].

The design of the 5,000-foot diversion provides for collection and transport of surface water runoff, access and a maintenance free rubble collection area. The final bench slope would be graded from the base of the highwall toward the diversion channel. A berm or row of large, non-acid producing rocks would be placed adjacent to the channel to act as a final barrier to prevent highwall rubble from entering the channel, yet still allow runoff to enter the channel unimpeded. The diversion channel is designed to be a long-term, maintenance free structure. However, as part of the overall post-closure maintenance, visual monitoring would be periodically conducted on the entire length of the channel and maintenance conducted as necessary.

Pit Floor Drainage - Although standing water in the pits has not been an operational problem in the past, there is a potential for periodic water in the pits. Water originating from groundwater seepage and precipitation would be collected in a sump and pumped to the treatment plant. If practical, this water would be directed out of the pit by gravity flow. In the event that this cannot be achieved, water would be pumped to a point where gravity flow can be used as a means to direct the water away from the pit area and to the treatment plant.

Upon reclamation, a free draining surface would be constructed using waste rock backfill. A pit floor channel would be sized to carry runoff from a 6-inch, 24-hour storm event and would be cement lined or lined with geotextile, clay and rip-rap. Pit wall runoff would return to the pit floor channel. All material within the zone of fluctuating water table would be non-acid forming or amended with limestone to be non-acid forming and would be sampled and analyzed in accordance with the waste rock sampling and handling plan (see Section 2.8.1.1). The pit floor diversion would be routed into the Ruby Gulch capture and contingency pond. Captured waters would be tested for quality. If water quality meets the MPDES discharge requirements, it would be released. If not, the water would be routed to the treatment plant. Maintenance of the diversion would include removal of sediment and repositioning of rip-rap as necessary.

Landusky Mine Pits

The expanded mining operation would require dewatering of the August pit. A dewatering well (95-LH-009) would be located at the southwest perimeter of the pit. Dewatering rates could be several hundred gallons per minute. Flow from the well would be piped by a 6-inch-diameter HDPE line to the 85/86 leach pad and added to the process circuit as makeup water, or treated (if necessary) and discharged into Montana Gulch. The following drainage diversions would be installed for expanded operations and reclamation at the Landusky Mine.

Above Pit Diversions - Where access allows, portions of the pit walls that are potentially acid forming and cannot be capped would have diversions installed above the highwalls. These diversions would prevent storm water from entering the pit. The diversions would be designed to be maintenance free. However, highwalls would be visually inspected on a periodic basis and repairs made as necessary.

Pit Floor Drainage - The final pit floor elevation prior to backfill proposed for the Queen Rose/Suprise pit is 4,600 feet and the August/Little Ben final pit floor elevation is 4,400 feet. An adit entering the old underground Gold Bug workings is located at an elevation of 4,580 feet and the August adit elevation is 4,604 feet. At cessation of mining, the pit complex (Queen Rose/Suprise, August/Little Ben) would be backfilled with approximately 939,000 tons of material, creating a final pit floor at approximately the 4,600 feet elevation. An engineered drain would be constructed into the existing August Adit, and the pit complex floor graded to flow into the engineered drain. The engineered drain and pit floor diversion would be sized for the 6-inch, 24-hour storm event. No reconditioning of the adit, other than establishing the engineered drain into the exposed adit in the pit highwall, is proposed because it is currently free draining. The adit portal is in Montana Gulch, buried beneath the Montana Gulch waste rock dump. Drainage from the August Adit would be captured in a pond near the tunnel mouth where it would be neutralized by lime addition or pumped back for treatment at a new Landusky Mine water treatment plant. The pond would be sized for a 6-inch, 24-hour storm event that includes runoff from the pit and underground workings.

Maintenance of the pit floor drainage would include removal of sediment and repositioning of rip-rap as necessary. Maintenance is not proposed after vegetation is established and sediment load eliminated. The engineered drain would be designed to be maintenance free.

Leach Pads

At the Zortman Mine, surface runoff water diversion ditches would be constructed upslope of the Goslin Flats leach pad and on the uphill (western and northern) perimeter of the pad, to divert runoff away from the facility. Diversion ditches would be sized for the 6-inch, 24-hour event. See Figure 2.8-7 for the locations of these runoff control systems. These operational diversions would remain in place upon final reclamation. Maintenance would not be necessary because no disturbance would occur in the drainage areas above the diversions.

No changes are proposed for operational surface water runoff control at the Landusky Mine. Storm water would be segregated from mine drainage by implementing best management practices and with construction of new drains along the east side of the Sullivan Park leach pad buttress. Upon reclamation, all diversions would be upgraded around the leach pads and laterally across the buttresses, sized for runoff from the 6-inch, 24-hour storm event.

Waste Rock Repositories

Permanent diversions associated with the proposed waste rock repository in Carter Gulch at the Zortman Mine are designed to minimize flow into or onto waste rock. Concurrent reclamation and temporary diversions, where feasible, are also planned as a means to limit infiltration of storm waters. Benches would be constructed with a 10H:1V backslope into the repository with a 1 percent gradient to the edge of the waste rock repository. The backsloped bench forms a channel designed to direct the 6-inch, 24-hour event off the facility to the natural drainage below the toe. Topographical and watershed breaks would be provided by the installation of 25-foot-wide constructed benches every 100 feet of vertical height, with the exception of the first lift construction which would be placed at a 125-foot interval. Benches would be constructed with 1 percent gradients allowing precipitation collections to be shed and transported towards common rock drainages constructed along the peripheries of the facility. Benches and peripheral drains would be sized for the 6-inch, 24 hour storm event. Benches would be sloped away from the waste rock repository face to control precipitation collections from flowing over the bench and down subsequent waste repository faces. Maintenance would include removal of sediment and repositioning of rip rap as necessary until vegetation was established. The benches would provide access for maintenance.

No changes are proposed to the existing drainage control features for the Gold Bug and Mill Gulch waste repositories at the Landusky Mine. No changes are proposed to the existing drainage control features for the Montana Gulch waste rock dump and the August waste rock dumps at the head of King Creek.

The top of the northeast portion of the Queen Rose repository would be sloped away from the face of the repository and routed to the northeast edge of the repository. A rip-rapped ditch 10 to 15 feet wide and 2 feet deep would be routed along the toe of the repository and drain to the August adit. A 30-foot wide intermediate bench would be placed at the 4,920-foot elevation and slope back into the repository at grades of 5 to 10 percent. The bench would be capped with clay or synthetic liner in a similar manner as the Gold Bug repository. The drainage from the intermediate bench would be graded to a drainage ditch located at the northeast edge of the repository. The top of the northern portion of the Queen Rose repository would be sloped away from the face of the repository and routed to the northeast edge of the repository. A rip-rapped ditch 10 to 15 feet wide and 2 feet deep would be routed along the toe of the repository and drain to the August adit. No intermediate benches would be constructed.

Water Capture

Capture systems consisting of ponds, diversions, slurry cut-off walls, and recovery wells would be used to capture mine drainage to prevent deterioration of water quality in adjacent drainages. Storm water would be segregated from mine drainage. Impacted water would not be released to surface water prior to treatment. Data would be collected in accordance with the monitoring plan to regularly monitor water quality and capture system effectiveness. Additional information concerning the capture systems is found in the Summary of the Water Quality Improvement Plan, Appendix A.

The location of most existing water capture structures would remain as described in Alternative 1. Existing capture and treatment systems would be expanded to capture and retain seepage associated with a 6-inch, 24-hour storm event. This would constitute an upgrade from the current capacity of most facilities to capture and retain seepage from a 2.5-inch, 24-hour storm event.

New capture systems would be constructed at the Zortman Mine below the proposed Carter Gulch waste rock repository and below the Goslin Flats leach pad. The Carter Gulch capture system would be located further downstream of the toe of the proposed Carter Gulch waste rock repository during construction of the waste rock storage area. A capture pond would be constructed to contain seepage from the 6-inch, 24-hour storm event in the event seepage waters were impacted

by the repository prior to final reclamation. Seepage volume is anticipated to be low since reclamation would take place concurrent with repository construction. Captured seepage water would be pumped to the Zortman water treatment plant for treatment and released into Ruby Gulch. Little maintenance would be required in the pond as storm water would be diverted around the lined area.

A new capture system would be constructed downstream of the proposed Goslin Flats leach pad. This system would be available to capture post-reclamation seepage from the leach pad after liner perforation if discharge water is contaminated by mine drainage or residual process chemicals.

No changes are proposed to the Ruby Gulch capture system. The Alder Spur capture system would be re-sized for seepage from the 6-inch, 24-hour event.

The existing seepage capture systems at the Landusky Mine, including Sullivan Park, Montana Gulch, Mill Gulch, and King Creek, would be sized to handle seepage generated by a 6-inch, 24-hour storm event. Seepage capture ponds and sumps would be inspected on a weekly basis for routine maintenance or repairs, if necessary.

Water Treatment

The location and function of the water treatment plants would remain as described in Alternative 1 and Appendix A. ZMI constructed a 2,000-gpm water treatment plant in May 1994 to treat seepage water captured at the toe of existing mine waste rock dumps at the Zortman Mine. The plant operates at a rate of 200 to 2,000 gpm depending on factors such as precipitation amounts and seasonal operating conditions. Another water treatment plant is planned for the Landusky Mine and would be located in the Montana Gulch area. Interim effluent discharge standards from the plant are BAT for mine waters (40 CFR §440.100). Establishment of final effluent limits and outfall points would occur as part of MPDES permit development.

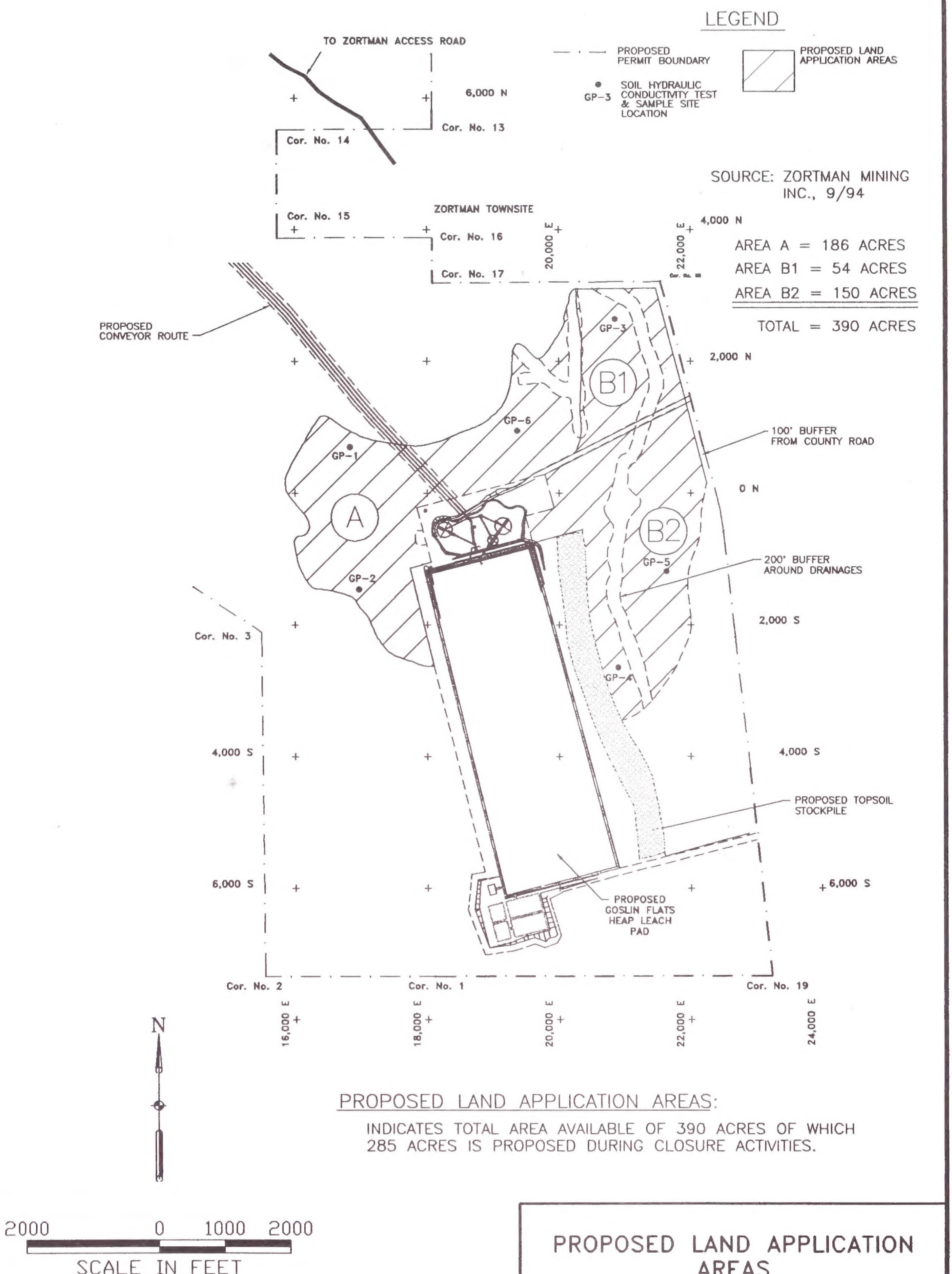
ZMI proposes to treat captured water of unacceptable discharge quality from the Landusky Mine at the Zortman water treatment plant until the new water treatment plant is constructed at the Landusky Mine. Landusky waters would be piped to Zortman via the existing pipeline, which would be rerouted due to expansion of the Zortman pit complex. The treatment process in use at the Zortman Mine can be summarized as lime precipitation. Low pH waters (i.e., those which are more acidic) are adjusted to a pH range of 6 - 9 and are clarified prior to discharge from the water treatment plant. The water treatment plant is designed to treat up to 2,000 gallons per minute of mine water, but the operating and discharge rate would depend on the quantity of mine water requiring treatment. See Appendix A for more detailed information on the water treatment plant operations, including a discussion on handling of the sludge produced from the plant and the interim water quality criteria to which the plant discharge water must adhere.

The water treatment plants would continue to operate until final reclamation measures have successfully produced effluent that meets the water quality standards. Under Alternative 4, with the placement of enhanced reclamation covers, long-term capture and treatment may not be necessary to meet water quality objectives in many of the affected drainages. However, it is provided for as a contingency. As water quality meets discharge standards and the appropriate agencies approve of release of the waters, capture ponds, sumps and pumpbacks systems would be dismantled and the sites reclaimed.

Land Application Disposal

Provisions for land application disposal are required by the regulatory agencies for final heap draindown at mine closure, or in the case of an extreme precipitation event that overwhelms the capacity of the leaching circuit. In the land application process, leaching solutions are treated with either hypochlorite or hydrogen peroxide to detoxify the cyanide. All solutions must be at or below 0.22 mg/l WAD cyanide prior to land application. Use of land application as a water management practice requires advanced notification and review by the regulatory agencies prior to each land application event to verify the character of the applied solutions, remaining soil attenuation capacity, and necessary monitoring techniques.

At the Zortman Mine, a total of 390 acres has been identified as suitable for use as a land application area while 285 acres near the Goslin Flats heap leach pad have been proposed for use as land application disposal sites during closure activities (see Figure 2.8-15). ZMI identified the area near Goslin Flats as part of a field reconnaissance study to locate a candidate land application site. Soil samples were collected from the site, analyzed for chemistry, and tested using treated barren solution to determine the soil's ability to adsorb and attenuate metals and cyanide. The soil was also tested for hydraulic conductivity to evaluate solution migration to the subsurface. A solution balance was calculated to determine metal loading and solution application parameters. This study is documented in Volume 7, Appendix 27, of the Zortman Mine Permit Application (Schafer and Assoc. 1993a).



PROPOSED LAND APPLICATION AREAS:

INDICATES TOTAL AREA AVAILABLE OF 390 ACRES OF WHICH 285 ACRES IS PROPOSED DURING CLOSURE ACTIVITIES.

PROPOSED LAND APPLICATION AREAS

173E0007

FIG. 2.8-15

No operational land application disposal is planned as part of the CPA. In the event that emergency land application of solutions is required, the land application area permitted for closure activities would be used. All neutralized effluents for disposal would have cyanide concentrations at or below 0.22 mg/l WAD. ZMI would notify the agencies prior to emergency land application. No emergency land application is anticipated during operations. In the unlikely event land application is required, it would be conducted as described in Alternative 1, Section 2.5.1.6 for currently permitted operations.

There would be minor disturbance to the land application area to gain access to solution pipelines. Solution pipelines would be removed and all disturbed areas would be reseeded.

Land application is not anticipated to be required for final heap draindown at the Landusky Mine. Draindown solution would be pumped to Goslin Flats leach pad and incorporated as process water. Section 2.8.1.4 contains additional information on solution transport between the Landusky and Zortman mines and the use of this solution at the Goslin Flats leach pad.

2.8.1.8 Hazardous Materials

A variety of potentially hazardous compounds would be needed for mining, ore processing, and reclamation activities at the Zortman Mine. Some of these compounds have been described in Alternative 1, Section 2.5.1.7. This section identifies the potentially hazardous materials and their projected use at the Zortman Mine. A discussion of the hazardous material usage, storage, handling, consumption, and waste disposal is presented in Section 3.14. The chemicals and their rate of use would be similar to historic uses, except that lime would replace sodium hydroxide for pH control, and the amount of flocculent would decrease.

Compound	Estimated Use
Lime	36,000 ton/yr
Sodium Cyanide	6,000 ton/yr
Gasoline	60,000 gal/yr
Hydrochloric Acid	33,000 gal/yr
Ca/Na Hypochlorite	Contingency use
Hydrogen Peroxide	Contingency use
Anti-Scalants	37,000 gal
Oil and Lubricants	40,000 gal/yr
Antifreeze	9,300 gal/yr
Flocculent	100 gal/yr
Citrus-base Solvent	800 gal/yr
Diesel Fuel	1.4 million gal/yr
ANFO	7,000 ton/yr

In addition, the following chemicals would also be used for the Zortman Mine expansion.

Sodium Hydroxide (caustic soda) is used in the stripping circuit to aid in desorption of gold and silver from the loaded carbon. The annual usage of caustic soda would be about 5,000 gallons.

Coagulant is used to settle small particles out of solution which can otherwise create problems in the clarifiers in the Merrill-Crowe plant. Since the new process ore processing system would rely solely on carbon adsorption, it is unknown how much coagulant would be needed to serve the same function in the carbon stripping circuit.

At the Landusky Mine, no changes are proposed from the current inventory and use of potentially hazardous materials. See Section 2.5.1.7, Alternative 1, for additional information.

Waste Disposal

No changes are proposed from the current disposal methods for solid and/or hazardous wastes at the two mines. See Section 3.14 for an expanded discussion of wastes produced and disposal methods.

2.8.2 Company Proposed Reclamation

ZMI's proposed reclamation plan includes actions to reclaim areas which have already been disturbed by previously permitted mine activities. The reclamation plan also describes actions for reclamation of disturbance which would be associated with the proposed expansion (described in Section 2.8.1). ZMI's reclamation plan includes the following land use objectives:

- Re-establishment of a vegetative cover appropriate to the area
- Permanent protection of air, surface water, and groundwater
- Protection of public safety and health
- Restoration of habitat compatible for grazing livestock and wildlife
- Design of land configuration compatible with the watershed
- Re-establishment of an aesthetic environment providing visual quality and recreation opportunities

Table 2.8-9 illustrates the proposed operating and reclamation schedule for the Zortman Mine. Final reclamation of all facilities is anticipated to be completed within 3 years after the Goslin Flats leach pad has been detoxified and liner perforated. Final reclamation of the Landusky Mine is anticipated within 3 years of detoxification of the 87/91 leach pad. A reclamation schedule is shown on Table 2.8-10.

Reclamation of individual facilities is contingent upon a number of economic and operational factors, and scheduling variations within the overall timeframe could occur. Reclamation activities are submitted to the DEQ on an annual basis and reflect the most recent operating and reclamation schedule.

Revised surface reclamation plans are proposed for all Landusky Mine facilities to implement improved reclamation techniques, with particular emphasis on enhanced reclamation covers to limit the potential for ARD generation. Although one focus of the reclamation plan would be to meet water quality management objectives with source controls and passive treatment measures, contingency plans are included for active water treatment.

Enhanced reclamation covers are required at both mines to prevent acidification of growth media placed during reclamation where acid forming materials are exposed. In addition, reclamation covers are proposed to limit infiltration, thereby minimizing the amount of seepage below facilities.

A number of operational systems have been installed or are proposed for both mines to ensure water quality protection. In addition to the enhanced reclamation covers proposed for some facilities, other water protection features include construction of operational drainages (versus post-operational drainages required under the current permit) which divert flows around leach pads, waste repositories and the pit complex, and capture systems which collect flows in two drainages. Contingency plans also exist for both active and passive water treatment.

The following sections describe the specific reclamation plans and actions proposed by ZMI for each of the major disturbance areas.

2.8.2.1 Reclamation Materials

Reclamation materials would be required for construction and installation of reclamation covers, and for use in construction of drains and solution diversions. The primary materials to be used would include non-acid forming waste rock and alluvial sediments, limestone, clays and cover soil. The following sections describe these materials.

Non-Acid Forming Material

Material designated "blue waste," considered by ZMI to be non-acid forming material, would be used primarily as a capillary break, although it would also be used as rip-rap in diversion ditches. The non-acid forming material would be mined as waste rock and stockpiled at the Carter Gulch waste rock repository for use during reclamation at the Zortman Mine and stockpiled adjacent to the Gold Bug waste repository for use in reclamation at the Landusky Mine.

Non-acid forming material used in reclamation of the Goslin Flats leach pad would be transported using the ore conveyance system from the stockpile at the Carter Gulch waste rock repository to the leach pad.

Limestone

Limestone, and other carbonate materials such as dolomite and calcareous shales, would be used without restriction in reclamation because of their potential to neutralize acidic solutions. Approximately one million tons of limestone would be mined from LS-1, south of Green Mountain and hauled to the Zortman Mine (see Figure 2.5-2). Approximately 5,300 feet of road would be upgraded and about 2,565 feet of new road would be constructed, for a total road disturbance of about 7,865 feet, as described in Section 2.7.2.1. Limestone or other carbonates for reclamation or construction of the Goslin Flats pad site would be transported from the mine site on the conveyor.

At the Landusky Mine, ZMI proposes to mine limestone from a quarry in the King Creek drainage. Material from this quarry would be used to construct drains or other facilities where a rock with high net neutralization potential is deemed desirable. This is a site where a quarry was previously permitted to provide materials for the King Creek public service project. Figure 2.5-2 shows the location of the proposed quarry site.

Limestone would be blasted, excavated and removed using ZMI equipment (Driltech C40KSH drills, Caterpillar 992 loader, Caterpillar D9N and D10N bulldozers and Caterpillar 777B haul trucks). The following materials would be disturbed:

The 2,500 feet of road from the haulage road into King Creek to the quarry site would be widened from 20 to 60 feet, with a disturbance of 5.7 acres resulting (assuming a 100-foot disturbance corridor). The disturbance in the immediate quarry area would be the quarry

TABLE 2.8-9
ZORTMAN MINE RECLAMATION SCHEDULE

Facility/Disturbance	Final Reclamation[1] (in years after approval)
Heap Leach Pads	
79, 80/81	Reclaimed
82	1
83	2
84	7 - 10
85/86	1
89	2
Goslin Flats Pad	7 - 10
Dike Faces	
82	7 - 10
83, 84, 85/86, 89	Reclaimed
Goslin Flats	1
Pit Complex	Concurrent with Operation
Waste Rock Facilities	
Ruby, Upper Alder Gulch, 82 Leach Pad Site	Reclaimed
Alder Gulch	Concurrent with Operation
Process Plant/Pond Sites	
Existing	7 - 10
Goslin Flats	7 - 10
Cover Soil Stockpile Sites	As used
Crusher Facility, Ore Storage Site, Conveyor Corridor, & Solution Pipeline	6
Limestone Quarry	7 - 10
Clay Pits	
Zortman Dump Site	Reclaimed
Seaford Clay Pit	7 - 10
Haul Roads/Access Roads	6 - 10
Refinery Site	7 - 10
Storage Sites	
Mine Equipment Storage & Service	7 - 10
Process Equipment Storage	7 - 10
Old Ruby Shop Site	2
Power Corridor	1

[1] The term "reclaimed" is used to mean that reclamation procedures have been fully undertaken for a particular disturbance in accordance with *existing* permit requirements. However, no facility can be considered fully reclaimed until the agencies have certified that reclamation goals and objectives have been achieved, at which time ZMI's reclamation bond would be released. The agencies have not provided evaluations of final reclamation success for any disturbances and no reclamation bonds have been released.

TABLE 2.8-10

PROPOSED OPERATING AND RECLAMATION SCHEDULE FOR LANDUSKY MINE

Facility	Operational Years (From Date of Approval)	Reclamation Years (From Date of Approval)[1]
Queen Rose, Suprise and August Pits	0 - 2.5	2 -3
South Gold Bug Pit	0	2
Gold Bug Waste Repository	0 - 2.5	0.5 - 3.5
Queen Rose Waste Repository	0 - 2.5	0.5 - 3.5
Mill Gulch Waste Repository	Not Used	In Progress
Montana Gulch Waste Dump	Not Used	1-4
August #1 and #2 Waste Dumps	0	3.5
Haul Roads	0 - 3.5	2.5 - 3.5
87/91 Leach Pad	0 - 5	5 - 8
85/86 Leach Pad	0	3
80-84 Leach Pad	0	2
83 Leach Pad	0	1
79 Leach Pad	0	1
Process Plants, Ponds and Storage Areas	0 - 7	8
Maintenance Shop, Warehouse, Offices, Parking and Storage Areas	0 - 7	4 - 8
Limestone Pits	0 - 7	8
Access Roads	0 - 8	0 - 8

[1] Subject to change based upon mine and operating plan.

Material	Depth	Fate
Cover Soil	2 - 4 feet	Repositioned during vegetation
Weathered Limestone	4 - 15 feet	Repositioned during resloping
Competent Limestone	15 - 50 feet	Used iin construction

pit and areas of sidecast and stockpiled material. Cover soil and weathered material would be sorted and positioned onto areas adjacent to the quarry. The quarried material would be stockpiled at the quarry site prior to usage. The following disturbances are anticipated at the King Creek site:

Disturbance	Acreage
Limestone Pit	2.0
Storage for Salvaged Materials	1.0
Storage for Limestone	1.0
TOTAL	4.0

This disturbance would be sufficient for excavation, storage and movement of up to 50,000 tons of limestone. Total disturbance for the King Creek quarry would be 9.7 acres (4.0 acres for the quarry pit and 5.7 acres for haul road).

Clay

Clay would be used at the Zortman Mine as liner material for the heap leach pad to contain the leaching solution, as well as cover material on waste rock repositories, heap leach pads, haul roads, and pit benches and floors to prevent moisture infiltration. Clay required for the Goslin Flats leach pad and reclamation would be mined from the Seaford clay pit. This source is on private property located approximately four miles south of the leach pad site and is permitted by the DEQ Opencut Bureau. ZMI has previously used the Seaford pit as a clay source for leach pad liner construction.

ZMI mine trucks or a mine contractor would use Seven Mile Road to haul clay from the Seaford pit to the Zortman Mine facilities (see Figure 2.5-2). The fleet of 85-ton trucks would have a 5.5-mile one way haul from the Seaford pit to the Goslin Flats leach pad. Clay hauled to the leach pad would not require travel through the town of Zortman. This trip would take about 30 minutes. Trucks would be grouped at the clay pit and final destinations, and travel as a convoy under the direction of front and rear pilot vehicles.

The Williams clay pit would provide bentonitic clays for use in reclamation covers. Up to 650,000 yd^3, or 850,000 tons, of material would be excavated from the pit, which is located approximately 2 miles west of the town of Landusky (see Figure 2.5-2). The clay would be hauled by ZMI truck and loader fleet, or contracted out to a truck and loader fleet, from the pit over the county road leading to the Landusky Mine, through the town of Landusky and onto the mine site to the area of final placement.

Trucks carrying from 50 to 85 tons of clay would be grouped at the Williams clay pit and Landusky mine site and travel as a convoy under the direction of front and rear pilot vehicles. The round trip haul time would be approximately one hour, and one convoy would make the trip each hour. Depending on reclamation requirements and schedules, clay would be hauled 24 hours per day.

Cover Soil

The cover soil stockpile located in Goslin Flats would provide the majority of cover soil for reclamation covers. The material would be hauled from the Goslin Flats stockpile to the mine site using ZMI or contractor equipment. The haul route would go through the town of Zortman and be approximately 4 miles. Trucks would be grouped at both the cover soil stockpile and mine site, and travel as a convoy under the direction of front and rear pilot vehicles. The round trip haul time would be approximately 30 minutes.

Cover soil would be salvaged as available during construction and reclamation activities at other facilities. The same equipment used for mining would be used to salvage soil, except at Goslin Flats where scrapers would be used to salvage suitable soil.

Cover soil stockpiles are located on the Landusky mine site and would not require haul traffic on county roads. A maximum of 460,000 yd^3 of cover soil would be required for reclamation capping. Cover soil collection and transport would be accomplished using ZMI or contractor equipment.

2.8.2.2 Reclamation Testing and Covers

All existing waste rock dumps, leach pads, buttresses, pit backfill and haul roads would be tested to determine if enhanced reclamation covers are required. Surface testing would occur on 100-foot centers on both a coarse (+1/8 inch) and fine fraction (-1/8 inch). Reclamation covers would not be used on surfaces and areas having

little or no potential for acid generation. Reclamation would consist of regrading (if necessary), cover soil and revegetation. An area having little or no potential for acid generation is proposed as one with no more than 10 percent of the tested material containing greater than 0.2 percent total sulfur. If surface sampling shows the material to contain less than 10 percent of 0.2 percent or less total sulfur, records would be checked to determine what material was placed in the facility based on mine modeling and production records. If records cannot be correlated, or results inconclusive, results of humidity cell testing (based on similar materials or materials taken from the facility) would be used to predict potential for acid generation. If humidity cell testing indicates the potential for deleterious impacts to water quality such as low pH and elevated metal content, the facility would be capped with the following covers.

ZMI would use one of three different reclamation cover designs, depending on the reclamation tests and slope of the reclaim surface. These covers, designated as Reclamation Cover A, Reclamation Cover B, and Reclamation Cover C, are depicted on Figure 2.8-16. A brief description of each cover and its potential application follows.

- <u>Reclamation Cover A</u> - Would be used on reclaimed haul roads and pit benches where acid forming material is identified in the cut surface. This cover consists of a barrier layer between the material covered and the overlaying salvaged soil. The sequence in this cover, from the lowest layer to the top, is:

  Bottom: Unamended substrate (the material covered)
  6 inches of compacted clay
  8 to 12 inches of cover soil

  Top: Revegetation with seed mixtures, fertilizers, and mulches

- <u>Reclamation Cover B</u> - Would be used on fill slopes with grades greater than or equal to 5 percent which require a barrier cover. The sequence, from the lowest layer to the top, is:

  Bottom: Fill or cut substrate with <0.5 percent sulfur (areas with >0.5 percent sulfur would be covered with 24 inches of yellow waste prior to capping)
  Two 6-inch lifts of compacted clay
  36 inches of non-acid forming material as a capillary break
  8 to 12 inches of cover soil

  Top: Revegetation with seed mixtures, fertilizers, and mulches

- <u>Reclamation Cover C</u> - Would be used on fill slopes of less than 5 percent that require a barrier cover. The sequence, from the lowest layer to the top, is:

  Bottom: Fill or cut substrate with <0.5 percent sulfur (areas with >0.5 percent sulfur would be covered with 24 inches of yellow waste prior to capping)
  3 inches of compacted clay
  One layer of 15 to 20 mil PVC liner material
  One layer of 5 ounce geotextile material (to resist punctures in liner)
  36 inches of non-acid forming material (capillary break)
  8 to 12 inches of cover soil

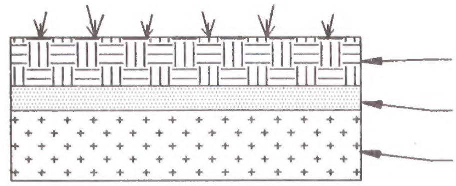
  Top: Revegetation with appropriate seed mixtures, fertilizers, and mulches

2.8.2.3 <u>Mine Pit Reclamation</u>

<u>Zortman Mine Pits</u>

Overall slope of the pit walls would be approximately 45 degrees (1H:1V) with 30-foot wide (flat) safety benches positioned every 60 vertical feet. Pit walls would be tested for acid generating potential by use of total sulfur analysis, static and leachate extraction tests. Surface water diversions would be installed to preclude runoff from contacting those portions of the pit walls that are potentially acid forming and which are too steep to be covered. Approximately 9 million tons of backfill material would be required to construct a pit floor with a free draining surface at about the 4,800 foot level. An estimated 5 to 6 million tons of waste material would be scheduled as backfill during mine operations. The remaining 3 to 4 million tons of backfill would come from the Carter Gulch waste rock repository and spent ore (approximately 100,000 to 500,000 tons) from the 85/86 leach pad after mining ceased and the pad has been detoxified. Information on grading, characterization, backfilling and cover of the pit floor is presented below.

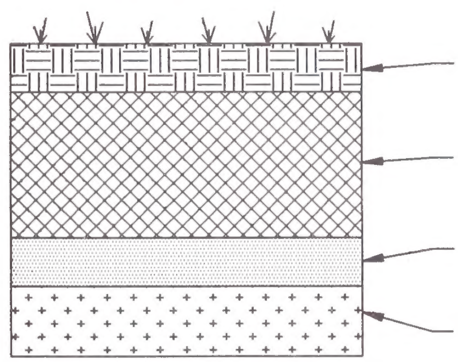
The final pit floors would be covered with Reclamation Cover B (as described in Section 2.8.2.2 and shown on Figure 2.8-17). After the pit floor is cover-soiled, it would be revegetated with native grasses and forbs chosen to enhance bighorn sheep habitat.



RECLAMATION COVER A

COVER FOR POTENTIALLY
ACID GENERATING SECTIONS
OF HAUL ROADS

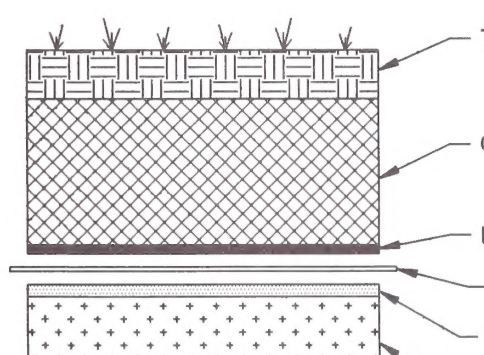
SCALE: 1"=4'



RECLAMATION COVER B

COVER FOR SLOPES 5 PERCENT
OR MORE ON WASTE ROCK
AND HEAP LEACH FACILITIES

SCALE: 1"=4'



RECLAMATION COVER C

COVER FOR SLOPES LESS THAN
5 PERCENT ON WASTE ROCK
AND HEAP LEACH FACILITIES

SCALE: 1"=4'

NOTE:

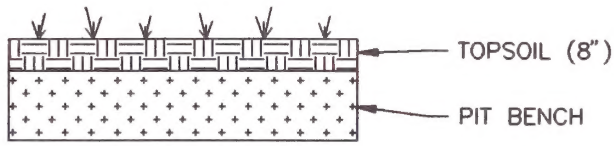
1. NAG – NON ACID GENERATING
   BLUE WASTE – LESS THAN 0.2% TOTAL SULFUR.

SOURCE: ZORTMAN MINING INC., 9/94

ALTERNATIVE 4
RECLAMATION COVERS FOR
WASTE ROCK AND HEAP
LEACH FACILITIES AND SELECTED
SECTIONS OF HAUL ROAD

173E004A

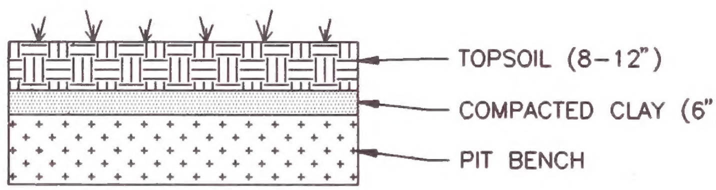
FIG. 2.8–16



PIT BENCH COVER

ABOVE 5000 FEET – ZORTMAN

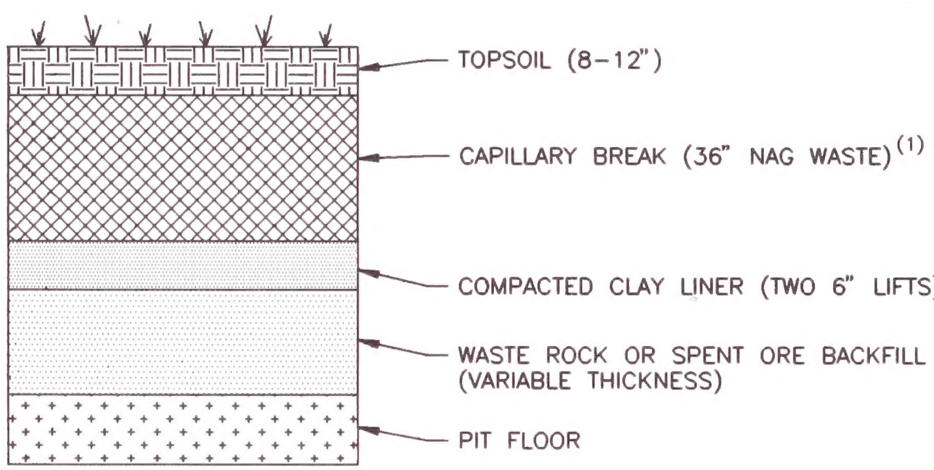
SCALE: 1"=4'



PIT BENCH COVER

BELOW 5000 FEET – ZORTMAN

SCALE: 1"=4'



PIT FLOOR COVER

ZORTMAN
(RECLAMATION COVER B)

SCALE: 1"=4'

NOTE:

1. NAG – NON ACID GENERATING

SOURCE: ZORTMAN MINING INC., 9/94

ALTERNATIVE 4
RECLAMATION COVER FOR
PIT BENCH AND FLOOR

173E005A

FIG. 2.8–17

Safety benches above the 5,000-foot diversion would be reclaimed concurrently with mining operations. Reclamation would include placing an average of 8 inches of cover soil on each bench and revegetation with a mixture of native grasses and forbs. Safety benches identified as potentially acid-forming below this elevation would be covered with Reclamation Cover A (see Section 2.8.2.2 and Figure 2.8-17) and revegetated with appropriate seed mixtures, fertilizers and mulches.

Landusky Mine Pits

ZMI began to backfill the Gold Bug pit with mine waste in February 1993. In addition to meeting the existing pit reclamation commitments in Alternative 1, all pit benches and pit floors would be sealed to limit surface water infiltration. Pits would be partially backfilled and the August adit used as drainage from the main Landusky mining complex (August/Little Ben and Queen Rose/Suprise pits) into Montana Gulch (see Figure 2.5-6). The following specific changes in the reclamation procedures are proposed:

1. Retreat reclamation and capping of benches
   During mining, bench areas identified as potentially acid forming would be capped with Reclamation Cover A. Benches identified as non-acid forming would receive 8 inches of cover soil before revegetation.

2. Backfill pits to the August adit elevation
   At cessation of mining, the pit complex (Queen Rose/Suprise, August/Little Ben) would be backfilled to the 4600 feet level. An engineered drain would be constructed into the existing August adit and the pit complex floor graded to flow into the engineered drain. No reconditioning of the adit is proposed as it is free draining. Discharge of the adit is in Montana Gulch. Discharge would be collected in a capture pond.

   The South Gold Bug pit would be backfilled to the 5,040-feet level from the pit highwall, to the 5,030-feet level at the pit daylight, using approximately 450,000 tons of waste rock. The pit floor backfill would be capped.

3. Capping and reclamation of the pit floor and backfill areas.
   The pit floor complex would be capped with Reclamation Cover B.

4. Installation of final diversions.
   Portions of the pit walls that are potentially acid forming and cannot be capped would have diversions installed above the highwalls, where access allows. These diversions would prevent storm water run-on.

2.8.2.4 Leach Pad Reclamation

Tasks associated with the reclamation of the heap leach facilities include heap detoxification, surface reclamation, and liner perforation.

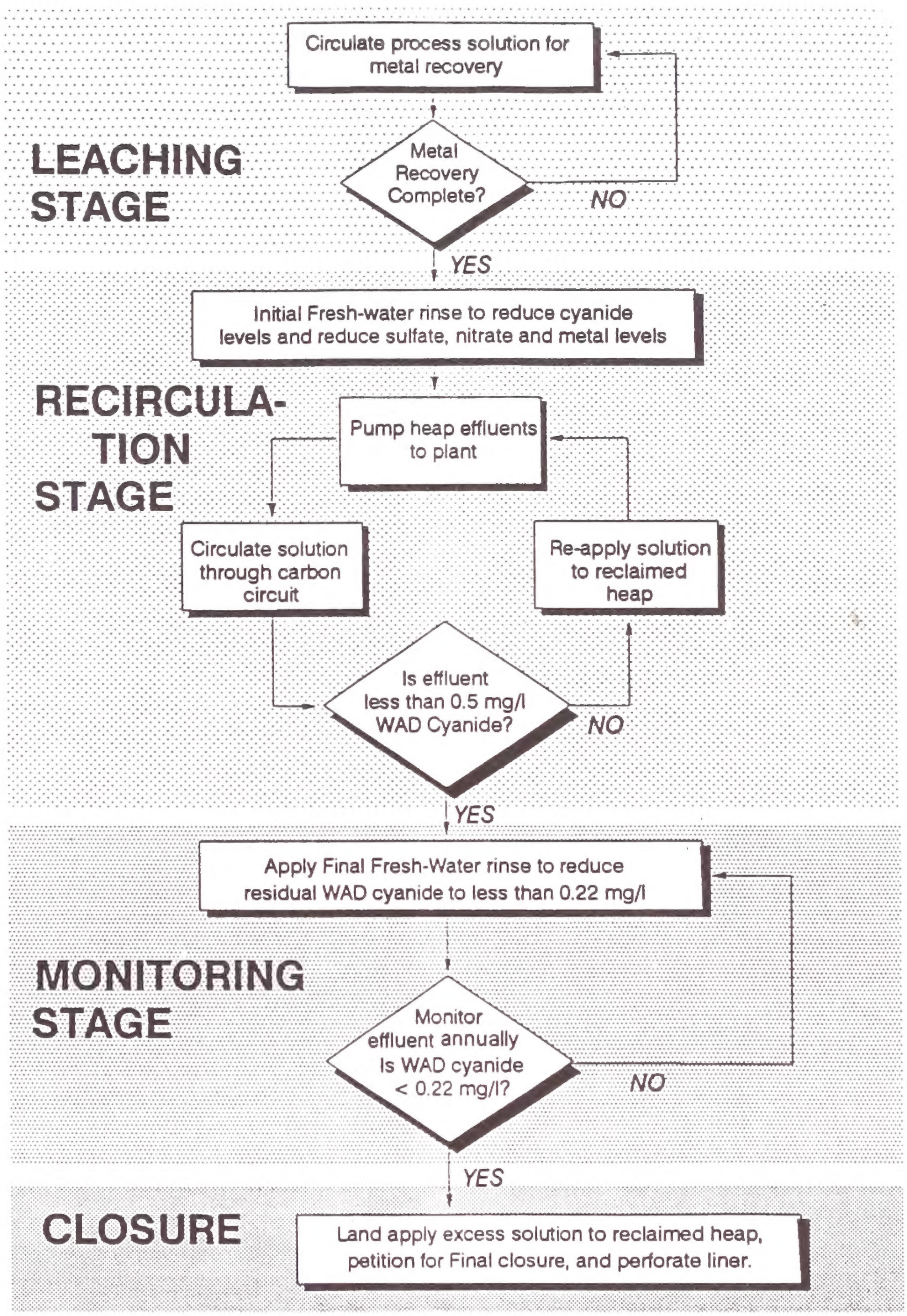
Heap Detoxification

Leached ore at both mines would be detoxified and reclaimed following the conclusion of processing. The detoxification process would take place in three steps: (1) an initial fresh water flush, (2) circulation of degraded pad effluents back through the system, and (3) a final circulation of cyanide free water to degrade and flush residual cyanide complexes from the heap. Figure 2.8-18 presents a flow chart depicting the leach pad detoxification process.

After ore leaching is completed, spent leach pad facilities would be decommissioned and flushed with fresh water to dilute process solution volumes contained within the pad. This fresh water flush would begin when recoverable precious metal concentrations are exhausted, and continue for 1 to 2 weeks until pad effluents have been reduced to approximately 50 percent of the normal process cyanide concentration.

Pad effluent solutions from the heap after the initial flushing cycle would be recirculated from the pad to plant processing facilities. Carbon recovery would be used in cyanide degradation by collection and containment of trace metal WAD cyanide complexes such as copper or zinc. Solutions pumped through the carbon columns would also be exposed to oxygen sources, promoting further cyanide decay through oxidation and volatilization. These solutions would be processed through the conventional carbon adsorption circuit used during operations for metal recovery. Solutions from the plant would then be recirculated to the decommissioned pad and applied to the heap surface through a riser sprinkler system.

The riser application system would also be used to aerate the effluent solution, promoting additional cyanide degradation by oxidation and volatilization. Recirculation of the decommissioned pad effluent would be conducted in batches, with periodic rest cycles to enhance natural cyanide degradation. An on/off spray schedule would be established during the spring, summer, and fall months to maximize cyanide degradation and solution evaporation. Due to the inability to predict precipitation events during these seasons, this schedule would have to be season-specific



SOURCE: ZMI AMENDMENT TO OPERATING PERMIT 00096 DATED 4/5/93.

SCHEMATIC FLOW CHART DEPICTING SOLUTION TREATMENT AND HEAP DECOMMISIONING

FIG. 2.8-18

so spray and rest cycles coincide with the seasonal precipitation. This spray schedule would continue until pad effluent concentrations maintain or fall below 0.5 mg/l WAD cyanide. When the solutions returning from the heap maintain less than or equal to 0.5 mg/l WAD cyanide, the heap would be flushed with cyanide-free water. Fresh water (cyanide free) flushing would continue until pad effluent concentrations remain at or below the 0.22 mg/l WAD cyanide guidelines.

The heap would be considered neutralized after the effluent concentrations remain at or below the 0.22 mg/l WAD cyanide guideline for a six-month period including one winter and spring runoff cycle. Heap solutions remaining after neutralization would be pumped from the heap to a pond for land application as a final solution disposal mechanism. Modifications to this plan could be made by ZMI as neutralization technology advances, and/or results of field neutralization further defines natural degradation and flushing efficiency of leach pad materials. Modifications in leach pad and solution neutralization would only be made after consultation with and approval of the appropriate regulatory agencies.

Surface Reclamation - Goslin Flats Leach Pad

Containment dike reclamation would be conducted concurrently with completion of dike construction. Dike slopes would be cover-soiled with an average cover of 12-inches and revegetated to blend with adjacent undisturbed contact zones and to reestablish vegetative communities. The slope of the containment dike around the Goslin Flats leach pad would not be reduced after ore processing ceases and would remain at an overall slope of 2.5H:1V.

Upon heap-detoxification, leach pad slopes would be graded from the constructed 2H:1V slope to 2.5H:1V. Slope reduction would be performed by track mounted dozers pushing the detoxified spent ore from the material crest or top down over the lift slopes utilizing cut and fill material from each of the facility benches. Spent ore would be pushed off containment to achieve the 2.5H:1V slope. Narrow, one-way haul roads to transport materials to the top of the heap leach facility during reclamation would be constructed. These haul roads would be reclaimed following completion of all other reclamation activities. Reclamation Cover B would be used on leach pad slopes greater than or equal to 5 percent, while Reclamation Cover C would be used on leach pad slopes less than 5 percent. The reclaimed pad surfaces would be revegetated with native prairie grasses, forbs and shrubs to complete final reclamation. In order to help mitigate the visual appearance of the reclaimed heap, portions of the uppermost lift(s) of ore would be varied in thickness and location to create a variable skyline. In addition, "micro-habitat" areas would be created by scouring small depressions with earth-moving equipment during final regrading.

Surface Reclamation - Existing Zortman Leach Pads

Several heap leach pads currently exist on the Zortman property. These include the 1979, 1980/81, 1982, 1983, 1984, 1985/86, and the 1989 pads. A portion of the material from the 1985/86 pad (100,000 to 500,000 tons) would be excavated and used as pit backfill. Reclamation of the other pads would include reduction of slopes to no steeper than 2.5H:1V. Leach pad re-sloping would not result in off-loaded pad materials being moved into natural or constructed drainages. Areas characterized as potentially acid-generating would be covered with Reclamation Cover B or C, depending on the degree of slope.

Surface Reclamation - Landusky Leach Pads

Leach pad slopes would be reduced in a manner such that off-loaded pad materials would not be moved into natural or constructed drainages. The reslope of the 87/91 pad extension would be conducted as part of the 87 and 91 individual pad reclamation projects. Final slope reclamation would be accomplished by a mixture of slope reduction and constructive reslope, with some materials pushed off of containment or placed into the mine pits as backfill.

Leach pad slopes would be reduced in the northern portions of the drainages that flow onto the Fort Belknap Indian Reservation. Approximately 3,900,000 tons of spent ore would be partially off-loaded and placed on the southern, western, and eastern areas to reduce the slope from 2H:1V to 2.7H:1V. Spent ore would not be placed off containment until the material was neutralized. Reclamation Cover B or C would be placed on the regraded leach pad if testing confirmed the necessity for a cover.

A 100-foot-wide buffer around the 1987 and 1991 pads would be required for reclamation access roads. There would be 28.7 acres of disturbance associated with this roadway. Capping sequences (Reclamation Cover B or C) would be installed where necessary over detoxified and regraded leach pads.

Liner Perforation

No changes are proposed for liner perforation for the 82, 83, 84, 85/86 and 89 leach pads at the Zortman Mine or the 80/82, 83, 84, and 85/86 leach pads at the

Landusky Mine. Perforation would not occur until water quality objectives have been met. Agencies would be consulted 90 days prior to liner perforation activities.

The Goslin Flats heap leach pad liner would be perforated after pad detoxification to eliminate moisture storage and any undesirable hydraulic conditions associated with the reclaimed facility. The liner would not be perforated until monitoring of the heap effluent indicates that water quality compliance has been met and risk of the formation of acid drainage is established to be minimal.

To perforate the liner, eight drain holes would be drilled through the pad's synthetic and clay liner systems at locations in the facility's collection basin to facilitate maximum moisture drainage. Each drain hole would be drilled to facilitate an 8-inch opening into the underlying drainage system. The process solution wells placed and installed during pad construction phase would be used for the liner perforation openings into the collection basin. These process wells would have a 12-inch hole milled from the well casing caps to allow for drill steel and bit penetration from the well casing into and through the underlying liner surface. Each perforated drain hole would be backfilled with sized drain rock to an elevation of at least 5 feet above the liner surface to ensure continued drainage.

The following activities would be conducted at Goslin Flats and the Landusky Mine 87/91 pads prior to liner perforation:

1. Water which collects in the sumps of reclaimed leach pads would be sampled on an annual basis.

2. The rate of phreatic surface rise would be monitored by annual measurement of phreatic surface elevations. Based on these measurements, the rate of infiltration into a reclaimed leach pad would be calculated.

3. After 10 years, if it is determined that water quality management objectives would be met for a given leach pad, the liner for that facility would be perforated.

4. If monitoring indicates that water quality management objectives would not be met, or if the rate of accumulation is such that dewatering of the leach pads becomes necessary before the 10-year monitoring period is reached, heap waters would be treated and/or discharged using the land application area.

Land Application

Following completion of all land application operations, the land application areas would be reclaimed. The pond liners would be removed and buried within the leach pads. Spray lines would be removed. All disturbances would be regraded to slopes no steeper than 3H:1V, which would then be cover-soiled and revegetated.

2.8.2.5 Waste Rock Repositories Reclamation

Carter Gulch Waste Rock Repository

At the Zortman Mine, reclamation of the Carter Gulch waste rock repository would be conducted concurrent with construction activities as a means of reducing the potential for ARD. As described in Section 2.8.1.5, construction of this repository would begin at the design toe. Initial construction would consist of an approximately 125-foot lift of waste to allow access to the area. Subsequent construction would be completed in 25-foot lifts with concurrent waste rock reclamation completed in sections every 100 feet of vertical height. Concurrent reclamation and utilization of 25-foot lift construction techniques would be used in an effort to minimize potential exposure to precipitation. In effect, use of the 25-foot lift construction techniques would provide additional areas of surface compaction due to haulage equipment traffic, in-turn yielding greater areas within the facility of low water permeability and porosity.

Waste repository slope lengths would be constructed at an angle of repose (1.5H:1V) along the original 125-foot lift and subsequent 25-foot lifts. The waste repository slopes would be regraded to an overall 3H:1V from the 4,800 foot elevation to the 5,100 foot elevation. This would include a 20-foot bench every 100 vertical feet with an inter-bench slope of 2.75H:1V. The slopes below the 4,800-foot elevation would remain at an overall 2H:1V slope. Topographical and watershed breaks would be provided by the installation of 20-foot wide constructed benches every 100 feet of vertical height or 200 feet of slope length, with exception of the first lift construction which would be placed at the 125-foot interval. Benches would be constructed with 1 percent gradients allowing precipitation to shed and be transported toward common rock drainages constructed along the peripheries of the facility. Benches would be sloped away from the waste rock storage area face to control precipitation collections from flowing over the bench and down subsequent waste repository faces.

In order to minimize precipitation infiltration into the repository facility, benches would be covered with Reclamation Cover B. Covered benches would be revegetated with native grasses, forbs and shrubs to control potential soil erosion and to develop wildlife habitat. Waste repository slopes would also be covered with Reclamation Cover B. Cover soiled slopes would be revegetated with native grasses, forbs and shrubs to enhance soil stability.

The top of the waste rock storage area, with a slope of less than 5 percent, would be covered using Reclamation Cover C. The facility top would also be revegetated with native grasses, forbs and shrubs.

Existing Waste Rock Dumps

At the Zortman Mine, three waste rock dumps (Alder Gulch, OK and Ruby Gulch) are currently located within the project boundaries. The Alder dump and Ruby sulfide stockpile would be moved to the Goslin Flats leach pad and the OK dump would be reclaimed in its present location. Specific activities at each location are as follows:

- Alder Gulch Waste Rock Dump - ZMI would remove the entire Alder Gulch dump, approximately 3.4 million tons of waste material, before this area is covered by the new Carter Gulch waste rock repository. The material removed would be relocated to the Goslin Flats leach pad for further ore processing. The leach pad would have sufficient capacity for this reprocessed ore.

- OK Waste Rock Dump - ZMI would characterize the surface material from the reclaimed OK waste rock dump on a 100-foot grid. Based on the results of the sampling and waste characterization, additional reclamation (to include cover placement) may be conducted on this dump, which contains approximately 1.2 million tons of waste material. Reclamation cover type would depend on the amount of total sulfur concentrations in the characterization samples, as described in Section 2.8.2.2.

- Ruby Gulch Sulfide Stockpile - The "sulfide stockpile," consisting of approximately 40,000 tons of material located on the southern portion of the Ruby Gulch waste rock dump, would be relocated to the Goslin Flats leach pad for further ore processing. The slopes on the remaining material (approximately 2.5 million tons) in the Ruby waste dump would be reduced to 3H:1V, where topographic considerations allow. The surface of the waste rock dump would be tested and reclaimed, with the extent of reclamation and reclamation cover type dependant on sulfur concentrations, as described in Section 2.8.2.2.

At the Landusky Mine, the designation and volume of waste rock material stored, and current reclamation status of the three waste rock facilities in the Landusky mining area are found in Table 2.5-8. Section 2.5.1.4 includes a narrative description for each of these facilities. Cover requirements for these facilities would be dependent on results of testing and the slope to be reclaimed. Section 2.8.2.2 provides more detail on each of these covers.

- Montana Gulch Waste Rock Dump - This valley fill waste rock dump was constructed during the years 1979 to 1987. Waste materials were end dumped with no attempt to segregate materials within the dump by size or geochemical characteristics. No barrier layers were included in reclamation covers for this facility when reclamation was conducted during 1988 to 1990. This facility would be tested as described in Section 2.8.2.2 within three years of project approval and, if necessary, capped with appropriate reclamation barriers.

- Mill Gulch Waste Rock Repository - The Mill Gulch waste repository currently contains 17 million tons of unclassified waste rock. This valley fill waste repository was constructed during 1987 to 1993, both by crest dumping and by lift addition. During 1990 to 1992 dump materials were amended with 2,600 tons of lime, which were placed on upper lifts of the dumps and ripped into the substrate. The existing interim cap, consisting of Reclamation Covers B and C, as described in Section 2.5.2.5, is proposed to be left as the final cap.

- Gold Bug Waste Rock Repository - Repository reclamation is proposed to continue concurrent with mining operations in the same manner as described in Section 2.5.2.5, Alternative 1. To minimize infiltration, the repository slopes would be sealed with Reclamation Cover B. The repository top would be capped with Reclamation Cover C. These caps are proposed as final reclamation. Capping and revegetation would occur as portions of the repository are completed.

- Queen Rose Waste Rock Repository - The Queen Rose waste rock repository is located within the previously mined northeast and north portions of the Queen Rose pit and entirely confined within the mined pit area. The repository contains approximately 3.2 million tons of waste rock from

operations under existing permit. An additional 4 million tons of waste rock would be placed in the repository for a total capacity of 7.2 million tons.

The base of the northeast portion of the repository is at the 4,700-foot elevation and the top is at the 4,980-foot elevation. The base of the northern portion is at the 4,720-foot elevation and the top is at the 4,840-foot elevation. The repository would be constructed from the base up in the same manner as discussed in the Gold Bug waste repository section. Blocks of material which are scheduled as green waste would be segregated within the repository interior. The margins of the repository would be constructed with yellow waste. Final slopes would be graded at 3H:1V with a 30-foot wide intermediate bench on the northeast portion of the repository at the 4,920 foot elevation.

Reclamation of the repository would be concurrent with mining for portions of the repository that would not be used as backfill for the August/Little Ben pit. Approximately 3.1 million tons of material would be required to backfill the August/Little Ben area from the 4,400-foot elevation to the 4,600-foot elevation. The final repository slopes would be capped with Reclamation Cover B. The final repository tops (with less than 5 percent slopes) would be capped with Reclamation Cover C. As the pit floor was to be capped with Reclamation Cover B, no changes in quantities for reclamation materials would be required.

- August #1 and #2 Waste Rock Dumps - The August #1 waste rock dump was constructed during 1984 and contains 700,000 tons of material. Waste materials were end dumped with no attempt to segregate materials by size, character, or placement within the dump. The waste material placed in the dump was taken in the early stages of mining and is oxidized. The August #1 waste rock dump has been recontoured at a 2H:1V slope. Final reclamation would consist of testing the surface to determine the need for reclamation capping. If it is not required, the dump surface would be covered with 8 to 12 inches of cover soil and revegetated with a mulch and tackifier base. If geochemical characterization indicates a cover is required, Reclamation Cover B will be used.

  The August #2 waste rock dump was constructed from 1980 to 1981 and contains 1,300,000 tons of material. Waste materials were end dumped with no attempt to segregate materials by size, character, or placement within the dump. The waste material placed in the dump was taken in the early stages of mining and is oxidized. The August #2 waste rock dump has been recontoured at slopes of 2H:1V to 2.25H:1V, cover soiled, and revegetated. The dump surface would be tested to determine the need for reclamation capping. If a cover is required, Reclamation Cover B would be used.

2.8.2.6 Support Facilities Reclamation

Solution/Process Ponds Reclamation

Process and contingency ponds would be perforated, backfilled with compacted material and graded. Alluvial material excavated during the pond construction would be used for backfill, along with concrete materials from structure footings or pads. The graded pond areas would be cover-soiled with an average soil cover of 8 to 12 inches and revegetated.

The carbon adsorption process for gold recovery generates little, if any, sludge. Sludges which might develop in processing ponds as the result of leach operations would be considered mine waste. The sludge would be sampled and a Toxicity Characteristics Leach Procedure (TCLP) performed to determine the mobility of any metals that may be present. If the TCLP analysis shows the sludge to be inert, it would be pumped to the leach pad for disposal prior to final cover of the heap. In the event mobile metals are present, the sludge would be fixed with cement, and the edge of the liner would be cut away from the anchor trench and folded over the cemented sludge prior to backfilling.

Process Plant Site Reclamation

Final reclamation would include the removal of all structures and equipment used in the mining and processing of ore through heap leach operations. Structures and equipment to be removed include:

- Existing processing plants, maintenance shop and support service structures
- Proposed crushing and processing facilities and equipment
- Proposed conveyer equipment
- Existing and proposed leach pad pumps and electrical structures
- Existing and proposed process spray and return lines

- Existing and proposed electrical power corridors (unless private, public, or regulatory agencies request continued use)

- Existing and proposed perimeter fencing of the property permit boundary

- Storage tanks and facilities

- Sediment control ponds and diversion ditches

All unoxidized bedrock exposed during construction activities and surfaces contaminated by spillage of non-oxide ore would be analyzed for total sulfur prior to reclamation activities. Materials shown to be potentially acid forming would be placed in the waste rock storage facility. Surfaces identified as potentially acid forming would be evaluated on a case-by-case basis and may be covered with Reclamation Cover A.

Reclamation of the process plant areas and service structures would include the dismantling and removal of all structures, concrete pads and footings. Concrete materials removed from the structures would be used for backfill materials for pond areas or disposed in an appropriate on-site waste disposal facility. All facilities would be dismantled and disposed as detailed below. The plant areas would be ripped by a track-mounted dozer, leveled and graded to facilitate surface drainage. Final graded areas would be cover-soiled with an average soil cover of 8 to 12 inches and revegetated to provide soil stability and re-establish vegetative communities.

It is estimated that 1,500 yd^3 of concrete would be removed and disposed. All steel structures would be salvaged or sold as scrap.

All solid waste generated during closure would be disposed in accordance with Montana laws and regulations of the DHES Waste Management Division. Inert waste (Class III, such as concrete, plastic, steel and wood) would be buried on-site in the Carter Gulch waste rock repository. Wastes not suitable for burial in a Class III facility, such as office waste and other Class II waste (household waste), would be transported to a landfill in the Lewistown area and disposed.

Soil Stockpile Reclamation

Cover soil stockpile locations would be ripped and revegetated after cover soil is redistributed.

Access and Haul Roads

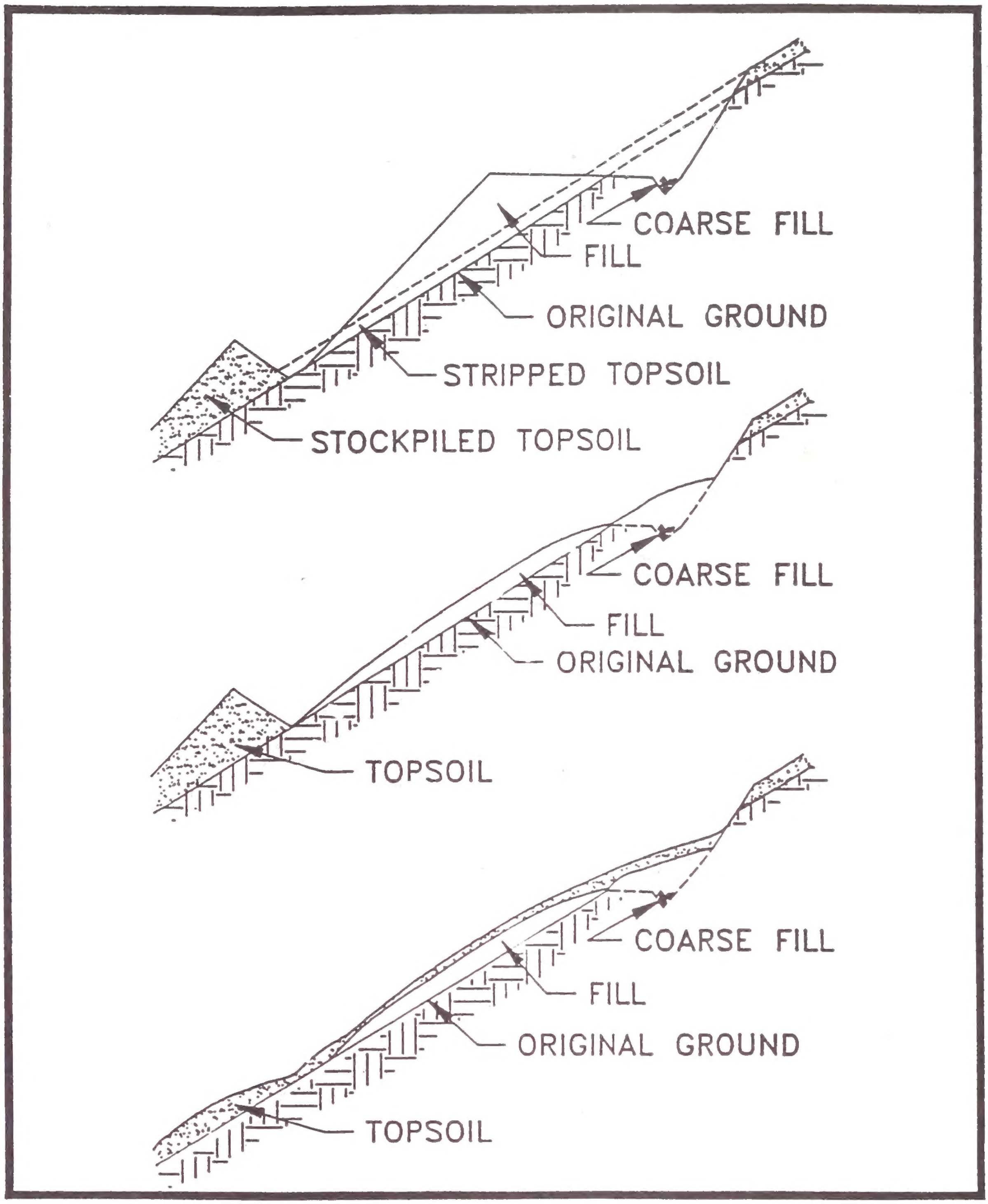
Haul and access roadways would be graded to re-establish natural drainage patterns. Roadways would be ripped to alleviate surface compaction and provide additional fill material for the drainage and grading of the roadway surface. Roadway berms and loose, unconsolidated material above and below the roadway cut would be pulled or dozed into the roadway using a backhoe or dozer. The amount of backfilling would be restricted by equipment limitations (e.g., slopes that can be traversed by dozers and by the backhoe reach).

Haul roads would be sampled and analyzed every 100 feet to determine if acid forming materials are in contact with soil. Areas of the haul roads that have been constructed in acid-generating material would be covered with Reclamation Cover A. All final graded areas would be covered with a minimum of 8 inches of cover soil.

Cover soil would be sidecast and the fill toed next to the cover soil (Figure 2.8-19). When reclamation is accomplished, the fill material is replaced into the cut area and the cover soil is then spread over the fill. Cover soil thickness varies according to the cover soil available when the stripping was done for the roadway. However, it is anticipated that cover soil would be placed at an average thickness of 12 inches and minimum thickness of 8 inches. Cover soil would not be hauled into areas for reclamation purposes with the exception of haul roads in the pit area. Haul roads left in the pits after completion of mining would be used for reclamation access to the pit. Final graded, cover soiled areas would be revegetated.

As previously described, three roadway sections connecting the Zortman, Landusky, and Hays townsite would remain after final reclamation. Sections of these roadway surfaces would be associated with operations haulage roadways. Such sections remaining after post-operations would be reduced from 70 feet wide to 25 feet wide. Therefore, the outer 45 feet of running surface would be ripped, contoured, cover-soiled, and revegetated.

The deviation from original topography from roadway reclamation varies significantly by site. Where haul roads, access roads and exploration roads are located in areas which require large cuts (10 feet or more); the roads generally would not be reclaimed to original contour. In contrast, roads located on gentle side hills or flats usually would be reclaimed to original contour.



SOURCE: ZORTMAN MINING INC., 9/94

TYPICAL CONSTRUCTION SEQUENCE FOR RECLAMATION OF HAUL AND ACCESS ROADS

FIG. 2.8-19

The reclamation plan for access and haul roads includes:

1. Where possible (see explanation above), roadways would be graded to original contour.

2. Haul roads would be sampled and analyzed for total sulfur every 100 feet to determine if acid forming materials are in contact with soil;

3. Haul road segments identified as potentially acid forming (greater than 0.5 percent total sulfur), would be covered using Reclamation Cover A.

Conveyor Corridor Reclamation

Reclamation of the conveyor corridor disturbances would include dismantling and removal of all structures, concrete pads, and footings at the Zortman Mine. Concrete materials removed from the structures would be used for backfill materials or disposed in the Class III disposal facility. Surface construction disturbances associated with cut and fill operations to facilitate conveyor routing would be recontoured and blended with adjacent landforms. Surface disturbance areas would be cover-soiled and revegetated with native grasses, forbs, shrubs, and trees.

Limestone Quarries

The ultimate facilities development topography of the limestone quarries is proposed to consist of a 1H:1V quarry wall with 20-foot-wide benches every 60 vertical feet on the northeast side of the quarry. The quarry floor would be graded at a maximum 5 percent slope to facilitate drainage and prevent ponding of water. Rock drains, rock lined swales, or other measures would be constructed as necessary to control erosion.

Cover soil would be placed to an approximate depth of 12 inches (8 inches minimum) on the pit floor and all quarry wall benches. With the exception of the benches, the quarry wall would not receive cover soil. The floor of the quarry would be scarified as necessary to reduce compaction and increase bond with the cover soil. Areas covered with soil would be revegetated.

Haulage access roadways connecting the quarry site with Zortman operations would be reduced to a running width of 25 feet along existing roadways. The outer 25 feet of running surface along the roadway would be ripped, contoured, cover soil with soil salvaged from the site and revegetated.

Reclamation of roadway disturbances would include reclaiming previously existing roads to a width of 25 feet and reclaiming new disturbances completely. Road reclamation would be similar to reclamation currently being done by ZMI on exploration drill roads. A Cat dozer would be used to push all the rock material into place, and then to spread the cover soil to approximate original contours. A track-mounted backhoe may be used where applicable.

Vegetation is proposed to include nine tree and shrub types, and a grass seed mix of seven grasses that are native to the area. Steps in the revegetation process are described in Section 2.8.2.8.

The King Creek limestone quarry would be reclaimed after mining has ceased. The salvaged materials (weathered limestone and cover soil) would be repositioned on the pit floor at a slope of 3H:1V or shallower. The post reclamation scarp heights on the limestone pits would vary from 0 to 30 feet. The disturbed areas would be revegetated with grasses, forb, trees, and shrubs as required in Section 2.8.2.8.

Clay Pits

An additional 4.3 acres would be disturbed for the proposed expanded operations at the Zortman Mine. Those areas in the clay pit already disturbed and reclaimed from previous operations would undergo additional reclamation; therefore, reclamation would be conducted on a total of 8.5 acres. A 3H:1V slope would be left after grading to allow runoff to proceed naturally downhill into the current drainage system. Cover soil would then be spread at an average of 18 inches, and a minimum cover of 12 inches, with vegetative seeding occurring during a seasonal period of higher precipitation. A seed blend of seven natural occurring area grass types would be used, as described in Section 2.8.2.8.

An additional 6.7 acres at the Williams clay pit would be disturbed for the maximum proposed reclamation. Those areas in the clay pit already disturbed and reclaimed from previous operations, about 25.6 acres, would undergo additional reclamation; therefore, reclamation would be conducted on a total of 32.3 acres. A slope no steeper than 2.5H:1V would be left after grading to allow runoff to proceed naturally into the current drainage system to the southeast of the pit. Cover soil would then be spread at an average of 12 inches, and a minimum cover of 9 inches, with vegetative seeding occurring during a seasonal period of higher precipitation. A seed blend of seven natural occurring area grass types would be used, as described in Section 2.8.2.8.

2.8.2.7 Reclamation Quality Control

ZMI or a mine contractor would place the clay covers at the two mines. This process would be monitored by a qualified, independent third-party engineering firm. The clay would be hauled from the clay pits and placed in compacted lifts (one 6-inch lift for Reclamation Cover A; two 6-inch lifts for Reclamation Cover B; and one 3-inch lift for Reclamation Cover C;). Each lift would be tested separately, approximately one test per acre. The clay would be drill tested for thickness by ZMI personnel with third party guidance. Drill holes would be backfilled with commercial grade bentonite. Clay thickness would be considered acceptable if there is a minimum of a 6-inch depth for Reclamation Cover A, 12-inch depth for Reclamation Cover B, or 3-inch depth for Reclamation Cover C, with reclamation depth at 90 percent of the sampling locations no less than 4, 9, or 3 inches at any location for Reclamation Covers A, B, or C, respectively. If an area does not have the minimum thickness, additional clay would be brought in and compacted to obtain the required depth. Compaction testing would be done by the third party inspector with a nuclear density gauge. Specifications would be for the clay to meet 95 percent density (Standard Proctor test) at 90 percent of the test locations. A minimum density would be 90 percent compaction.

ZMI personnel would install the synthetic liners (15 to 20 mil PVC) at the two mines. Installation of the synthetic liner would also be monitored by a third party inspector. Seams would be air-lanced to ensure a good bond was achieved between field seamed PVC sheets. Areas having inadequate bonding, cuts or punctures would be repaired and tested until passed by the third party inspector. The entire area would be visually inspected and passed prior to cover with geotextile.

ZMI, or a mine contractor overseen by ZMI personnel, would install the capillary break in the reclamation covers at the two mines. The capillary break thickness would be 3 feet over 90 percent of the area covered, with a minimum thickness of 2.5 feet at any location.

Monthly construction reports with testing results would be provided to the agencies.

2.8.2.8 Revegetation Procedures

Areas disturbed by mining-related operations would be revegetated to stabilize soil and slopes, reestablish communities ecologically comparable to pre-mine conditions, and restore watershed, wildlife, recreational and aesthetic values that meet post-operation land use objectives. The following sections describe ZMI's proposed revegetation program.

Species Selection

ZMI has developed permanent seed mixes to reestablish grassland and/or forest settings on each disturbed area. The plant species used in revegetation would depend on land use objectives, presence of the species on pre-mine disturbances, plant establishment potential, growth characteristics, stabilizing qualities, wildlife palatability and commercial availability. Interim seed mixes would be used on sites where soil stabilization is desirable prior to final reclamation.

Mountainous Areas - Table 2.8-11 shows the seed mixture selected for the mountainous areas disturbed by Zortman Mine operations. The seed rate used is based on broadcast rate of 150 to 170 Pure Live Seeds per square foot of coverage; the rate would be halved for drill seeding. Annual ryegrass would be seeded into mountainous sites at a rate of one pound per acre to provide rapid initial slope and soil stabilization. Tree and shrub species would be planted rather than seeded.

Goslin Flats Vegetative Species - Table 2.8-12 shows the seed mixture selected for the relatively flat areas disturbed by Zortman Mine operations. The seed rate used is based on broadcast rate of 150 to 170 Pure Live Seeds per square foot of coverage; the rate would be halved for drill seeding. Tree and shrub species would be planted rather than seeded.

Seedbed Preparation

Seedbeds would be prepared immediately after the area to be revegetated has been graded, cover soil, and fertilized. On gentle slopes (flatter than 3H:1V), the seedbed would be disced and harrowed along the contour to break up large clods. On steeper slopes, areas too narrow to negotiate equipment, or on sites where organic debris has been respread, the soil surface would be left in a roughened condition. The resulting irregular seedbed would provide areas for plant germination and also reduce soil movement on steeper slopes. Seed and mulch would be applied to fresh road cuts and fills in areas subject to erosion as soon after construction as possible to prevent natural sloughing.

Seeding Methods

Seeding would be coordinated with other reclamation activities to occur as soon after seedbed preparation as possible. Fall seeding would be emphasized, while spring seeding would occur if areas are ready for revegetation and access is possible.

TABLE 2.8-11
SEED MIX AND SEEDING RATE FOR MOUNTAINOUS AREA - ZORTMAN

Species	Common Name	Variety	Seed Rate Lbs/PLS	Seed Rate PLS/ft^2
Grasses				
Agropyron cristatum	Crested wheatgrass	Ephraim	2.0	10
Agropyron riparium	Streambank wheatgrass	Sodar	8.0	29
Agropyron trachycaulum	Slender wheatgrass	Revenue	5.0	18
Bromus biebersteinii	Meadow brome	Regar	10.0	9
Festuca ovina	Sheep fescue	Covar	2.0	31
Lolium multiflorum	Annual ryegrass	---	1.0	5
Stipa viridula	Green needlegrass	Lodom	5.0	20
Forbs				
Lotus corniculatus	Birdsfoot trefoil	---	2.0	20
Linum lewisii	Lewis flax	Appar	2.0	14
Achillea millefolium	Common yarrow	---	0.1	6
Astragalus cicer	Cicer milkvetch	Lutana	1.0	4
Total Grasses & Forbs			**38.1**	**166**
Shrubs[1]			**Planting Rate**	
Juniperus communis	Common juniper			
Amelanchier alfnifolia	Serviceberry			
Prunus virginiana	Chokecherry			
Rosa woodsii	Wood's rose			
Symphoricarpos occidentalis	Snowberry			
Total Shrubs[1]			**400 stems per acre**	
Trees[2]			**Planting Rate**	
Pinus Ponderosa	Ponderosa Pine			
Pinus contorta	Lodgepole pine			
Pseudotsuga menziesii	Douglas-fir			
Total Trees[2]			**400 stems per acre**	

PLS = Pure Live Seed

[1] Planting rate for shrubs is a combination of any or all species listed, depending on site characteristics

[2] Planting rate for trees is a combination of any or all species listed, depending on site characteristics

TABLE 2.8-12
SEED MIX AND SEEDING RATE FOR GOSLIN FLAT - ZORTMAN MINE

Species	Common Name	Variety	Seed Rate Lbs/PLS	Seed Rate PLS/ft^2
Grasses				
Agropyron dasystachyum	Thickspike wheatgrass	Critana	8.0	28
Agropyron spicatum	Bluebunch wheatgrass	Revenue	8.0	26
Agropyron trachycaulum	Slender wheatgrass	Revenue	2.0	7
Bouteloua gracilis	Blue grama	Lovington	1.0	19
Poa sandbergii	Sandberg bluegrass	---	1.0	21
Stipa comata	Needle-and-thread	---	3.0	8
Stipa viridula	Green needlegrass	Lodom	4.0	16
Forbs				
Achillea millefolium	Common yarrow	---	0.1	6
Linum lewisii	Lewis flax	Appar	2.0	14
Petalostemon purpureum	Purple prairie clover	---	1.0	7
Ratibida columnaris	Prairie coneflower	---	0.1	6
Total Grasses & Forbs			**30.2**	**158**
Shrubs[1]			**Planting Rate**	
Artemisia tridentata	Big sagebrush			
Artemisia cana	Silver sagebrush			
Rhus trilobata	Sumac			
Rosa arkansana	Prairie rose			
Total Shrubs[1]			**400 stems per acre**	

PLS = Pure Live Seed

[1] Planting rate for shrubs is a combination of any or all species listed, depending on site characteristics

Broadcast (including hydroseeding) and drill seeding methods would be used, although the majority of disturbances would be broadcast seeded. Broadcast seeding would occur on rocky areas, slopes steeper than 3H:1V, areas where organic debris has been respread, and small disturbances. Seed would be broadcast using manually operated cyclone-type bucket spreaders, mechanical seed blowers, or hydroseeders. When possible, broadcast seeded areas would be chained or harrowed to cover the seed. Where slope conditions allow, seeded areas would be dozer-tracked perpendicular to the slope. Seed would be covered by hand raking on smaller, less accessible sites.

Drill seeding would be done along contour wherever the reclamation surface is not level to achieve proper seed placement depth and promote good contact between seed and soil. Drill row spacing would range from 7 to 14 inches. Drill seeding would not be used in areas where reclaimed surface have rocky soil or where organic debris has been re-spread.

When hydroseeding is used, the seed, fertilizer, and mulch would be sprayed in one application of about 250 lbs/acre. Where hydromulching is used, a second mulch application accompanied with a tackifier binding would be sprayed along the disturbance at manufacturer's recommended application rates.

Planting Methods

Trees and shrubs would be planted using two techniques: (1) as clumped plantings on leach pads (except for Goslin Flats), waste rock storage area, and plant site crests and tops; and (2) as continuous rows along sloped areas such as dike faces and the leach pad recontoured slopes. Trees and shrubs would not be planted on road cuts and cover soil stockpiles. Shrubs would be reestablished in the prairie grass community associated with the reclaimed tops and slopes of the Goslin Flats operations.

Tree species would be planted continuously across slopes such as dike faces, sloped areas of leach pads (except for the Goslin Flats leach pad), and waste repositories, and in clumps along level areas such as plant sites, and the tops of leach pads and waste repositories. Heap leach pads (with the exception of Goslin Flats) and waste repository tops would be planted in islands on level areas, with 10 to 30 percent of the area planted in forest species and the remainder planted in grasses for wildlife grazing. Distribution of the various tree species would depend on slope, reclamation surface, and moisture conditions.

ZMI would initially plant 400 trees per acre. Based on an anticipated survival rate of 65 percent, the final stocking rate after 15 years would be about 260 trees per acre. The appropriate planting time would be determined by site conditions such as soil moisture, soil temperature, air temperature, site accessibility, and previous reclamation planting experiences with trees and shrubs at Zortman Mine disturbances. Tree stock would be delivered to the site as close to the time of planting as possible, with no stock handled when the air temperature is below freezing and no planting when frost is still in the soil. Hand tools and power-driven augers or similar machines would be used to plant trees and shrubs. Mulching could be employed to conserve moisture and reduce competition.

If available, stock inoculated with mycorrhiza would be planted to enhance growth and prospects for plant survival. Partial shade from logging debris, snags, or other sources would be used to help establish seedlings. If tree seedling survival is less than 65 percent three years after planting, supplemental planting would be considered.

Cultural Treatments

ZMI would use surface ripping techniques, fertilization, and mulching to enhance revegetation success potential. Ripping would be conducted on soil stockpile sites, road surfaces, and other areas where compaction has occurred. Compacted soil on level areas would be tilled to break up the soil mass and improve water and air movement through the subsurface.

Fertilizer mixes and application rates would be based on soil tests; rates would be formulated to achieve soil macronutrient levels capable of promoting plant growth and productivity. Mulch would be spread evenly over seeded areas at rates dependent on seeding method and slope. Mulch would be anchored into the seedbed using a mulch crimper, disc, or tracked dozer. A tackifier would be applied on areas that are mulched in the fall and on areas which require prompt stabilization.

Noxious Weed Control

Noxious weeds would be controlled throughout the life of the operation by mechanical methods or chemical application by licensed personnel. Revegetated areas would be qualitatively evaluated on an annual basis to assess weed populations. A weed control plan has been developed by ZMI and reviewed by the Phillips County Weed Management program which outlines procedures for management of noxious weed infestation on mine property. ZMI would evaluate and control noxious weed populations on reclaimed areas until the reclamation bond is released on the reclaimed sites.

In most respects, revegetation procedures for reclaimed areas at the Landusky Mine would be as described for the Zortman Mine. Areas disturbed by mining-related operations would be revegetated to stabilize soil and slopes, reestablish communities ecologically comparable to pre-mine conditions, and restore watershed, wildlife, recreational and aesthetic values that meet post-operation land use objectives. The only difference for Landusky revegetation from that described for the Zortman Mine is in seed mixtures and broadcast rates. The seed mixture selected for the Landusky Mine would be broadcast at approximately 180 Pure Live Seeds per square foot. Table 2.8-13 presents the revegetation mixture and seeding/planting rates for the Landusky Mine.

2.8.3 Monitoring Programs and Research Studies

Section 2.5.3 provides a description of the monitoring programs and research studies ongoing at the Zortman and Landusky mines. The following sections describe only programs and studies which would be conducted in addition to the existing program, or proposed modifications to the existing programs.

2.8.3.1 Water Resources Operational Water Monitoring

The operational water monitoring program as currently defined would continue during expansion and reclamation of the Zortman and Landusky mines. Water resources monitoring, including sites already added to the program to collect data for the extension projects, would continue as described in Section 2.5.3.1. Changes to the monitoring frequency and chemical analytes could occur depending on the requirements of the final MPDES permit.

If revisions to the monitoring program are needed or in the event that existing monitoring sites or wells must be decommissioned due to mining operations, regulatory agencies would be consulted and appropriate replacement sites would be selected.

Post-Reclamation Water Monitoring

The purpose of post-reclamation water resource monitoring would be to verify the effectiveness of reclamation in maintaining the quality of water resources. This monitoring program would concentrate on those drainages downgradient of the heap leach pad facilities and waste rock facilities (e.g., Goslin Flats, Ruby Gulch, Alder Gulch).

Post-operation monitoring would use wells and stream stations which have been used during baseline and operational monitoring programs. This would ensure continuity of data and provide for comparison between pre-mining, mining and post-mining water resource systems. At present it is anticipated the final monitoring network would consist of the following monitoring sites (see Tables 2.5-13 and 2.5-14 and Exhibits 1 and 2 for a key to the locations of these sites):

Zortman Sites

- Surface Water: Z-1B, Z-2, Z-5, Z-8, Z-15, Z-16, Z-16A, Z-18, Z-20, Z-21, Z-22, Z-27, Z-28, Z-31, Z-32, and Z-42
- Groundwater: ZL-110, ZL-141/142/143, ZL-145, ZL-147,ZL-148, ZL-149, ZL-150, ZL-153, ZL-209, ZL-210,AG-200,AG-201,AG-202, AG-203, RG-110, and RG-111

Landusky Sites

- Surface Water: L-2, L-7, L-8, L-9, L-11, L-16, L-19, L-23, L-36, L-37, and L-39
- Groundwater: ZL-109, ZL-113, ZL-133, ZL-139, ZL-155, ZL-156, ZL-157, ZL-162, ZL-164, ZL-165, and TP-1

Monitoring sites may be revised based on the results of operational monitoring, which would identify sites most sensitive to environmental impacts. Diagnostic sampling parameters identified during operational monitoring would be used for post-operation water resource monitoring.

After reclamation and closure activities have commenced (immediately after cessation of mining activities), post-mining monitoring would go into effect. Post-mining monitoring would consist of four periods of monitoring as described below:

Period 1 — Immediately after completion of mining and leaching activities (including perforation of the heap leach pad liner), monthly monitoring would take place for one year in the leach pad, waste rock repository and pit areas. This would provide post-mining water quality data.

TABLE 2.8-13
SEED MIX AND SEEDING RATE FOR LANDUSKY MINE REVEGETATION

Species	Common Name	Variety	Seed Rate Lbs/acre	Seed Rate PLS/ft^2
Grasses				
Agropyron dasystachyum	Thickspike wheatgrass	Critana	5.0	18
Agropyron spicatum	Bluebunch wheatgrass	Secar	5.0	16
Agropyron trachycaulum	Slender wheatgrass	Revenue	4.0	14
Agrostis alba	Redtop	---	0.20	22
Bromus marginatus	Mountain brome	Bromar	6.0	13
Festuca ovina	Sheep fescue	Covar	2.0	31
Lolium multiflorum	Annual ryegrass	---	2.0	10
Orizopsis humenoides	Indian ricegrass	Nezpar	5.0	16
Forbs				
Lotus corniculatus	Birdsfoot trefoil	---	2.0	20
Linum lewisii	Lewis flax	Appar	2.0	14
Achillea millefolium	Common yarrow	---	0.1	6
Total Grasses & Forbs			**33.3**	**180**
Shrubs[1]			**Planting Rate**	
Arctostaphylos	Kinnickinnick			
Juniperus communis	Common juniper			
Amelanchier alfnifolia	Serviceberry			
Prunus virginiana	Chokecherry			
Rosa woodsii	Wood's rose			
Symphoricarpos occidentalis	Snowberry			
Total Shrubs[1]			**400 stems per acre**	
Trees[2]			**Planting Rate**	
Pinus contorta	Lodgepole pine			
Pseudotsuga menziesii	Douglas-fir			
Total Trees[2]			**400 stems per acre**	

PLS = Pure Live Seed

[1] Planting rate for shrubs is a combination of any or all species listed, depending on site characteristics

[2] Planting rate for trees is a combination of any or all species listed, depending on site characteristics

Period 2 If no water quality changes are detected in the first year of monthly monitoring, or if water quality improves, quarterly monitoring would be conducted for a period of one year.

Period 3 If no water quality changes are detected, or if water quality improves during the first year of quarterly monitoring, semi-annual monitoring would be conducted for a period of three years. Semi-annual monitoring would be conducted during the spring (May-June) and fall (October-November).

Period 4 After year 5, monitoring would continue on an annual basis until the reclamation bond has been released, which would occur after neutralization of process solutions and reclamation have been successfully carried out and the water meets the requirements set forth in the MPDES permit.

A final design of the post-operation monitoring plan would be prepared near the end of the mining operation. Post-operation water resource monitoring would be continued until reclamation bond is released on the specific disturbance which the stream station or groundwater well is monitoring. Any changes proposed to the post-operation monitoring plan would be submitted to DEQ and the BLM for review and approval prior to implementation.

Heap Leach Pad

A monitoring program would be implemented for the spent ore pad to determine the quantity and quality of seepage through the materials; provide a basis for design of mitigation measures, if necessary; and to monitor any potential long-term changes.

Monitoring instrumentation would consist of neutron access tubes installed near the base of the facility, pressure-suction lysimeters placed a critical depths to monitor soil moisture quality below specific zones, and existing wells downgradient from the facility to monitor any potential impact to groundwater. Frequency of monitoring would be quarterly for the first year, semi-annually until apparent equilibrium conditions occur, and annually until bond release.

Carter Gulch Waste Rock Repository

A monitoring program would be implemented for the waste rock storage area to determine the quantity and quality of seepage through the materials; provide a basis for design of mitigation measures, if necessary; and to monitor any potential long-term changes.

Monitoring instrumentation would consist of neutron access tubes installed to the base of the facility, pressure-suction lysimeters placed at critical depths to monitor soil moisture quality below specific zones, and wells downgradient from the facility to monitor any potential impact to groundwater. Frequency of monitoring would be quarterly for the first year, semi-annually until apparent equilibrium conditions occur, and annually until bond release.

2.8.3.2 Reclamation Surface Performance Study

Section 2.5.3.2 describes the history and intent of the RSPS, including actions which have been initiated (primarily in Stage 1 (Help Model Evaluation) and Stage 2 (Preliminary Field Trials), and those planned to begin soon (primarily Stages 3 (Comprehensive Field Trial) and 4 (Operational Monitoring). The RSPS would be continued during the expansion projects.

2.8.3.3 Surface Reclamation Monitoring Revegetation

Revegetated areas would continue to be evaluated by field reconnaissance during the first season following seeding or planting to determine initial revegetation success. First year monitoring would include visual observation of overall germination and planting success. During the second season, monitoring would include quantitative and qualitative evaluations of canopy cover, species composition and tree planting success. Areas with poor germination and/or growth would be evaluated to determine causes of any unsuccessful revegetation. The agencies would be consulted and reclamation techniques would be modified to address any identified problems. Attempts to revegetate problem areas would be made until successful. Thereafter, monitoring would be conducted biannually until vegetation composition is stable.

Revegetation mixtures may be modified, with approval of MDSL and the BLM, to reflect plant material availability and other factors, including evaluation of initial revegetation success.

Soil
Vegetative characteristics such as vigor, color, growth rate, and post seedling emergence would be observed to monitor soil fertility. If plant nutritional deficiencies appear, micronutrient testing would be included in the sampling program and appropriate corrective measures would be taken.

Water Control Structures
All water control structures including diversions, exclusion berms, sediment traps and culverts would be periodically inspected and maintained to ensure that they are functioning properly.

Subsidence
Subsidence of reclaimed areas is not anticipated since ample time would be allowed prior to reclamation to allow any preferential settling or subsidence of the structure to occur. In addition, reclamation parameters associated with slope stability and regrading would reduce the possibility of slope subsidence on such areas as heap leach facilities and waste repositories. Monitoring for subsidence of reclaimed areas would be conducted during reclamation monitoring. Any subsidence noted during reclamation monitoring would be corrected and reseeded.

2.8.3.4 Air Quality Monitoring

Section 2.5.3.4 provides a description of the air quality monitoring program for the Zortman and Landusky mines. No changes to the existing program would be implemented for the Zortman and Landusky expansion projects.

2.8.3.5 Wildlife Monitoring

Section 2.5.3.5 provides a description of the wildlife monitoring program for the Zortman and Landusky mines. No changes to the existing program would be implemented for the Zortman and Landusky expansion projects. Expansion facilities would be included in the wildlife monitoring program.

2.8.4 Reasonably Foreseeable Future Actions

2.8.4.1 Powerline Upgrade

Big Flat Electric Cooperative has informed BLM that expansion of the Zortman Mine may cause the Cooperative to propose additional electrical transmission lines into the project area. Although the Cooperative says that the existing system is adequate to meet the anticipated power needs of the mine, additional powerlines could be proposed to improve the electrical service reliability. This action would only be reasonably foreseeable if the Zortman Mine expansion was approved. A summary of the project follows.

Big Flat Electric Cooperative would construct a 53-mile, 69-kV transmission line from the Malta Western Area Power Administration Tie Substation to the Goslin Flats (SSR Engineers 1995). Figure 2.8-20 shows the route of the proposed powerline. The majority of the 69-kV line would parallel Highway 191 along existing right-of-way. The powerline would be diverted south away from Highway 191 where it enters the Fort Belknap Indian Reservation. The new right-of-way would run south and east of Coburn Butte, then turn west along the south side of Ricker Butte. The powerline would end in the Goslin Flats area.

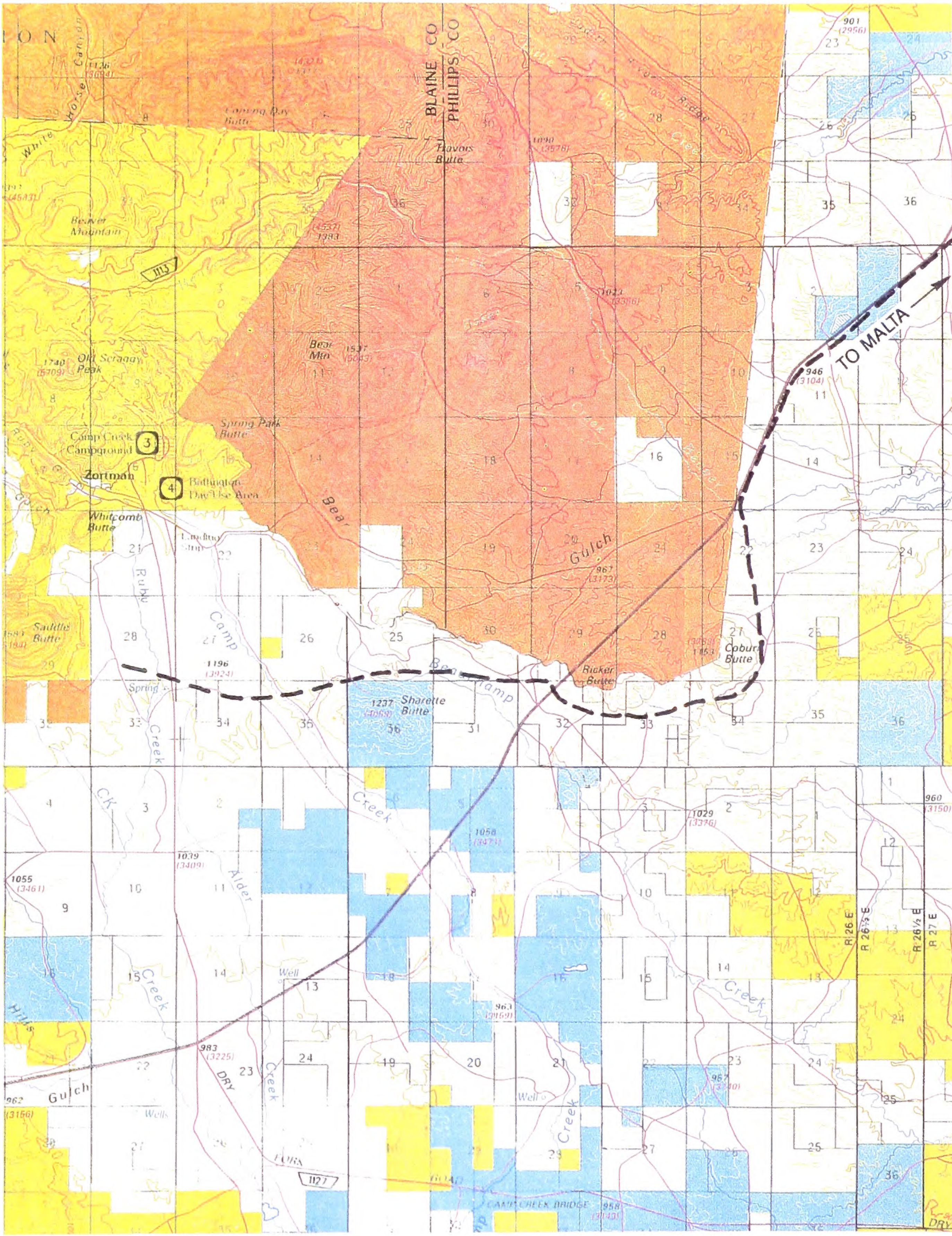
Single wood pole structures approximately 55 feet tall would be used. The powerline right-of-way would be 50 feet wide. Approximately 15 poles would be installed every mile, depending on the terrain. The poles would be installed by drilling a truck mounted auger into the ground.

2.8.4.2 Mine Activities

At the Zortman Mine, a proposal to mine the 2-million ton ore deposit in the Pony Gulch area is foreseeable (see Figure 2.8-1) because facilities to process the ore in Goslin Flats would be in place. Methods similar to those described in earlier sections would be used to mine this deposit; the ore would then be crushed and placed on the conveyor for transport to the Goslin Flats leach pad to be processed.

Proposals for vertical or lateral expansion of the Goslin Flats leach pad are foreseeable should substantial amounts of additional ore be identified through the foreseeable exploration program.

Proposals for development of a new limestone source on the ridge above Zortman, or enlargement of the



POWERLINE

SOURCE: SSR ENGINEERS, 1995

REASONABLY FORESEEABLE 69KV POWERLINE

FIG. 2.8–20

proposed Green Mountain limestone quarry, are foreseeable (see Figure 2.5-2). This material would be used to provide non-acid generating construction material for maintenance of drainage control structures. The quarrying of additional limestone resources could total as much as 1 million tons should there be a shortage of suitable waste rock for construction and reclamation purposes. Limestone may be used for capillary break material, rip-rap for drainages, under-drains, and/or as buttress material.

Proposals for construction of passive water treatment systems such as wetlands or anoxic limestone drains down gradient of the Zortman mine facilities are reasonably foreseeable as a means of mitigating effects from ARD. This would likely occur at the closure and post-closure phases of mine life.

At the Landusky Mine, proposals for the mining and leaching of additional ore are foreseeable. It is likely that ZMI would propose to mine an additional 12.2 million tons of ore and 8 million tons of waste rock at some future date, as some evidence exists that additional mineable ore is present at the Landusky Mine. This would be mined from the existing mine pits.

A leach pad to contain the 12.2 million tons of ore would probably be proposed either within an existing mine pit or at some other suitable location. It would be technically feasible to construct an in-pit leach pad in the Queen Rose/Suprise pit. Alternatively, spent ore from present leach pads could be off-loaded after detoxification, thereby providing additional room for new ore leaching. Spent ore off-loaded from the leach pads could be disposed in the mine pits as backfill.

Construction of a new leach pad would likely occur on existing disturbed ground and would involve mining of additional clay for leach pad liner. Crushing of some ore would be necessary to provide a protective layer over the pad liner.

Waste rock associated with foreseeable mining activity would be proposed for disposal in the existing Gold Bug waste rock repository or used as pit backfill in the South Gold Bug Pit. However, subsequent drilling could extend the bounds of the pit and may affect the viability of pit backfilling.

Additional limestone quarry operations (beyond the 50,000 tons which is proposed in Alternative 4) are foreseeable. This would be to obtain a source of NAG material for construction-reclamation purposes should current projections for NAG waste rock amounts be in error. At the King Creek quarry, this could involve mining of an additional 550,000 tons of limestone. A proposal to develop a new limestone quarry in Montana Gulch is also foreseeable. This quarry site would likely be located in the NW¼, SW¼, of Section 22, T25N, R24E (see Figure 2.5-2). This site is within the current Landusky Mine permit boundary. Another 550,000 tons of limestone may be proposed for mining from this new quarry. This would raise the final quarry disturbance to 10 acres for the King Creek quarry and 7 acres for the Montana Gulch quarry.

Due to ongoing discussions between ZMI and the DEQ, the drainage control and capture systems may be proposed for revision to ensure attainment of new effluent limits. This could involve additional capture ponds, storage ponds for active water treatment facilities, storm water discharge settling ponds, and constructed wetlands.

Sludge from the water treatment plants would probably continue to be disposed by burial in the existing leach pads. New sludge disposal areas would be proposed once existing sites are filled.

A landfarm for remediating petroleum spills is a reasonably foreseeable development at the Landusky Mine. The landfarm would be sited on the east side of the 85/86 leach pad. Agencies would be notified prior to use and ZMI would obtain approval from the Montana DEQ Waste Management Division prior to each use of the landfarm.

2.8.4.3 Exploration Activities

In 1991, ZMI submitted for agency consideration a long-term exploration program designed to assess areas of potential economic mineralization throughout that portion of the Little Rocky Mountains outside the Fort Belknap Reservation. ZMI withdrew the proposal in 1992 as a result of their decision to prioritize exploration efforts elsewhere. Since there has been no change in the basic geology and economic conditions that gave rise to the exploration proposal, it is included here as a reasonably foreseeable activity. While the details of this comprehensive exploration project would not be identical to the 1991 proposal, the overall concept would be as follows:

Under this alternative, it is likely that exploration activities would be targeted on those areas adjacent to the conveyor route. This may result in identification of a minable deposit that could be accessed by the conveyor and leached at Goslin Flats. New exploration activities could occur over a 10-year period, and disturb approximately 128 acres. The greatest amount of

activity (and disturbance) would likely be in the area between the existing Zortman and Landusky mines.

Geologic anomalies in some of the more remote areas in the Little Rocky Mountains would first be tested with small portable drill equipment, brought on-site by helicopter. This would determine if larger scale exploration was warranted. Up to ten sites would be tested with shallow (less than 100 foot) drill holes.

Overall, exploration could involve 200,000 linear feet of road construction, 5,000 linear feet of trenching, and 600 drill holes over a 10-year period (Table 2.8-14). New road construction would use bulldozers to build roads with bed-widths between 12 and 16 feet. Side-cast and road cuts would increase the average disturbed width to 25 feet. Road grades would average less than 8 percent with approximately one-tenth of the roads being as steep as 8 to 25 percent.

The combined existing and foreseeable exploration activity could disturb 155 acres of land. The primary earthen material to be disturbed is topsoil, alluvium, and scree. Each of these materials would be removed during the construction phase of road building, trenching, and drilling, and stored on site for final reclamation.

Exploration trenches would be constructed using dozers to expose bedrock. Trench widths and depths would be approximately 15 feet, with individual trench lengths no greater than 250 feet.

Drilling would occur predominately within a constructed roadbed using track-mounted and buggy-mounted, reverse-circulation drilling equipment. These holes would be drilled to depths of approximately 300 feet. More than one hole may be drilled from a single drillsite. Off-road drilling would use skid-mounted, and large truck and track-mounted equipment, requiring approximately level drill pads 65 by 65 feet. These holes would be drilled to depths of approximately 600 feet. Drilling would use either air or water as a circulating medium depending on localized lithologic and hydrologic conditions. Standard drilling fluid additives would be used.

Down-hole geologic data would be collected by sampling, assaying, and describing drill cuttings. Approximately 5 percent (30) of the drill holes would be core sampled.

The maximum amount of new construction that would occur in any given year is shown in Table 2.8-15. At no point would yearly construction exceed 27 acres of disturbance.

2.8.4.4 Exploration Reclamation

Reclamation would be performed on a yearly basis concurrent with ongoing exploration and mineral evaluation. Unreclaimed land for any year would not exceed 71 acres, with this acreage decreasing substantially during the final four years of the project. A reclamation schedule is presented in Table 2.8-16.

Roads - Exploration roads would be recontoured using either rubber-tired backhoes, traxcavators and/or track-mounted dozers. Side-cast materials, deposited down slope of the roadway during construction, would be pulled back into the road cut. As the roadway slope is either backhoed or dozed into place, the final reclaimed surface would approximate the original contour.

Reclaimed roads associated with stream drainages crossed during construction would have culverts removed and the drainage recontoured to allow for continual surface flow. Additional soil stabilization techniques would be used in these areas to prevent erosion until vegetative cover is established. Such techniques include the placement of straw (free of noxious weeds) upstream of the surface crossing to reduce stream flow velocities or use of erosion control blankets such as excelsior, hemp mat or other geotextile materials to ensure adequate transfer of surface flows across the reclaimed area.

Trenches - Trenches constructed during exploration by track-mounted dozers would be backfilled, recontoured and revegetated during reclamation. Rubber-tired backhoes, rubber-tired loaders, traxcavators, and/or trackmounted dozers would be used to fill and recontour trench excavations with materials end-dozed or side-cast during the construction phase of exploration. Topsoil material stripped from the site and stockpiled during construction would be distributed along the recontoured surface prior to revegetation. Final reclamation surfaces would be revegetated to provide soil stability and reestablishment of vegetative communities.

Off-Road Drill Sites - Off-road drill sites constructed for deep hole (up to 600 feet) exploration would be recontoured and revegetated to blend with adjacent undisturbed landforms. The above mentioned equipment would be used to recontour the disturbance prior to revegetation. Final recontoured sites would be revegetated to provide soil stability and reestablishment of vegetative communities.

TABLE 2.8-14
POTENTIAL EXPLORATION DISTURBANCE

Category	Currently Disturbed	Foreseeable Disturbance	Totals
Roads	47,940 ft 27.5 acres	200,000 ft 114.8 acres	247,940 ft 142.3 acres
Trenches	400 ft 0.3 acres	5,000 ft 3.1 acres	5,400 ft 3.4 acres
# Drill Sites:	137	500	637 sites
Off Road Drill Sites:	0	100	100 sites
Total Disturbances			
Linear Feet	48,340	205,000	253,340
Acres	27.8	127.6	155.4
No. of Sites	137	600	737

TABLE 2.8-15
MAXIMUM NEW CONSTRUCTION BY PROJECT YEAR[1]

Year	Roads (ft)	Trenches (ft)	In-Road Drillsites	Off-Road Drillsites
0[2]	47,940	400	137	0
1	35,000	1,000	150	40
2	35,000	1,000	150	40
3	35,000	1,000	150	40
4	35,000	500	150	40
5	25,000	500	100	25
6	25,000	500	100	25
7	25,000	500	100	15
8	25,000	500	50	15
9	10,000	500	50	10
10	0	0	0	0

1 Estimates shown represent maximum values for individual years. The total exploration disturbances shown in Table 2.9-14 would not be exceeded.

2 Year "0" represents existing conditions.

TABLE 2.8-16
FORESEEABLE EXPLORATION RECLAMATION SCHEDULE

Year	Roads (ft)	Trenches (ft)	Off-Road Drillsites	Acres/Year
1	12,940	400	0	7
2	15,000	500	10	10
3	25,000	500	10	16
4	25,000	500	10	16
5	35,000	500	10	21
6	35,000	500	10	21
7	30,000	500	10	19
8	30,000	500	10	19
9	25,000	1,000	15	16
10	15,000	500	15	10
Total	247,940 ft	5,400	100	155

Revegetation would be established on all disturbed areas except scree slopes. Seeding would be coordinated with other reclamation activities to occur as soon after recontouring and seedbed preparation as practical. Seeding would normally be conducted in fall (after Oct 15) or spring (prior to May 1) depending on weather conditions. All spring seedings would be conducted as early in the season as possible to maximize use of early precipitation. The majority of seeding would be manually broadcasted. Hydroseeding may be used in certain areas.

Streams affected by exploration activity would be recontoured and revegetated. All exploration drill holes would be plugged completely from bottom to top where groundwater is encountered.

Drill hole closure and abandonment would be conducted in accordance with the Montana Hard Rock and Placer Exploration License Manual: Requirements, Policies, Procedures and General Information, Drill Hole Plugging Policy (June 21, 1993). In summary, all holes must be plugged at the surface, 5 to 10 feet with cement. Bentonite or a similar material from the bottom to within 5 to 10 feet of the surface.

All solid waste material (i.e., plastic, wood, metal, etc.) would be removed from the area on a continual basis and disposed of properly. Used hydrocarbon products would be transported from the area to be disposed of in accordance with pertinent regulations.

2.9 ALTERNATIVE 5: MITIGATED EXPANSION AND RECLAMATION WITH LEACH PAD LOCATED IN UPPER ALDER GULCH RATHER THAN ON GOSLIN FLATS

Alternative 5 would allow expansion of both the Zortman and Landusky mines but impose agency-developed mitigations on the expansion and reclamation activities. The major modification to ZMI's expansion plans (see Alternative 4, Section 2.8) would be at the Zortman Mine, where the proposed ore heap leach facility at Goslin Flats would instead be placed within Upper Alder Gulch. The agencies developed this alternative as a means of mitigating visual and noise impacts, and effects on wildlife associated with construction and operation of the leach pad and conveyor system to Goslin Flats. A significant modification of the Landusky reclamation requirements would be for ZMI to remove rock fill from the head of King Creek and backfill the pits to a minimum elevation required to create a surface which would freely drain into King Creek. Other mitigating measures are incorporated into this alternative, including many of those described in Alternative 3. Figure 2.9-1 and Exhibits 1 and 2 show the existing and proposed facilities at both mines associated with this alternative.

Many of the plans and facility designs for Alternative 5 are similar to or the same as those described in Alternative 4, and are hereby incorporated into this alternative. Therefore, the description of expansion and reclamation facilities is tiered to the discussion presented in Section 2.8. The focus of discussion for this alternative is on those areas which would be modified from the Company Proposed Action (CPA). The proposed mine expansions and facilities modifications are presented in Section 2.9.1, followed by the proposed reclamation activities for each mine as described in Section 2.9.2. Modifications to ZMI's proposed monitoring programs and research studies are described in Section 2.9.3. Section 2.9.4 contains an assessment of other activities which are reasonably foreseeable should Alternative 5 be implemented.

2.9.1 Mitigated Mine Expansions

The location and currently permitted area of the Zortman Mine and the proposed Mine expansion with relocation of the leach pad to Upper Alder Gulch, are shown on Figure 2.9-1 and Exhibit 1, located in the map pocket of this document. The total new disturbance for the Zortman expansion would be approximately 1,350 acres including buffer zones around disturbance and 405 acres previously disturbed under the existing permit.

ZMI has proposed several changes to current operations at the Landusky Mine, including provisions for mining an additional 7.6 million tons of ore and 7 million tons of waste rock. Service facilities to support these operations would include a limestone quarry and expanded shale pit excavations. The location of the currently permitted mine area is shown on Figure 2.9-1 and Exhibit 2, located in the map pocket of this document. The quantity of ore to be mined under this application would constitute slightly less than one year of additional mining at the Landusky Mine. No additional workers are anticipated to be hired.

Under this alternative ZMI would continue to use open-pit mining and heap-leach mineral processing to extract gold and silver from ore, as described in Section 2.8.1. Because this alternative includes many elements common with Alternative 4, mine operations are summarized with reference to more complete descriptions in Section 2.8.1. Additional detail is provided where a modification from the CPA is included. Most of the discussion is centered on expanded operations at the Zortman Mine, since there would be little modified from the Landusky Mine operations described in Section 2.8.1. The major modifications from the Proposed Action include:

- The 80-million ton capacity heap leaching facility for the Zortman Mine would be constructed in Upper Alder Gulch as a valley fill leach pad, rather than at Goslin Flats.
- Ore from the Zortman Mine would be transported to the heap leach pad by truck (rather than by conveyor system, as proposed in Alternative 4).
- The Zortman Mine ore crushing facility would be sited in the vicinity of the pit complex.
- Enlargement of the solution processing plant at the Zortman Mine to include a carbon adsorption circuit.

Zortman Mine Expansion - Ore production would be approximately 60,000 to 80,000 tons per day, with mining and leaching operations performed on a year-round basis. Mining and related operations would take place 7 days a week, 24 hours per day, 350 days per year. ZMI projects that the CPA work force would be similar to current operations, with approximately 260-280 full-time employees, depending on seasonal requirements. Modifications to the mine expansion should not measurably change the rate of operations or the work force.

Landusky Mine Expansion - The significant modification to the CPA under this alternative concerns water control and treatment. Post-reclamation runoff would be routed into King Creek instead of the August Drain tunnel.

2.9.1.1 Mine Pit Expansion

Mine pit expansion at the Zortman Mine would not change from that described in Alternative 4, Section 2.8.1.1. The edges of the pit would be extended outward 600 or more feet from the current pit configuration. The pit would be deepened approximately 500 feet in some ore zones, to a lowest point of about 4,500 feet. A plan view of the pit complex was shown on Figure 2.8-3, with pit cross-sections displayed in Figures 2.8-4 and 2.8-5.

The proposed mine pit expansion for the Landusky Mine would involve lateral and vertical expansion of the existing Queen Rose/Suprise and August/Little Ben pits, and the South Gold Bug, which is an extension of the existing Gold Bug Pit. A plan view of the ultimate pit complex was shown on Figure 2.8-6, with typical cross sections of the pit expansions in Figures 2.8-7 and 2.8-8.

Mining Methods

Conventional open-pit mine methods (drill, blast, and transport) would be used. The mining description provided in Alternative 4, Section 2.8.1.1 is applicable to this alternative unless otherwise noted in specific sections.

Rock Characterization

The materials and their relative amounts to be mined during expanded operations at the two mines were described in Alternative 4, Section 2.8.1.1. The geochemical sampling and waste rock characterization program proposed by ZMI, and described in Section 2.8.1.1, would be implemented under this alternative. (Mitigations have been added restricting the use of certain waste rock types in reclamation. See Section 2.9.2.1)

Waste Rock Handling

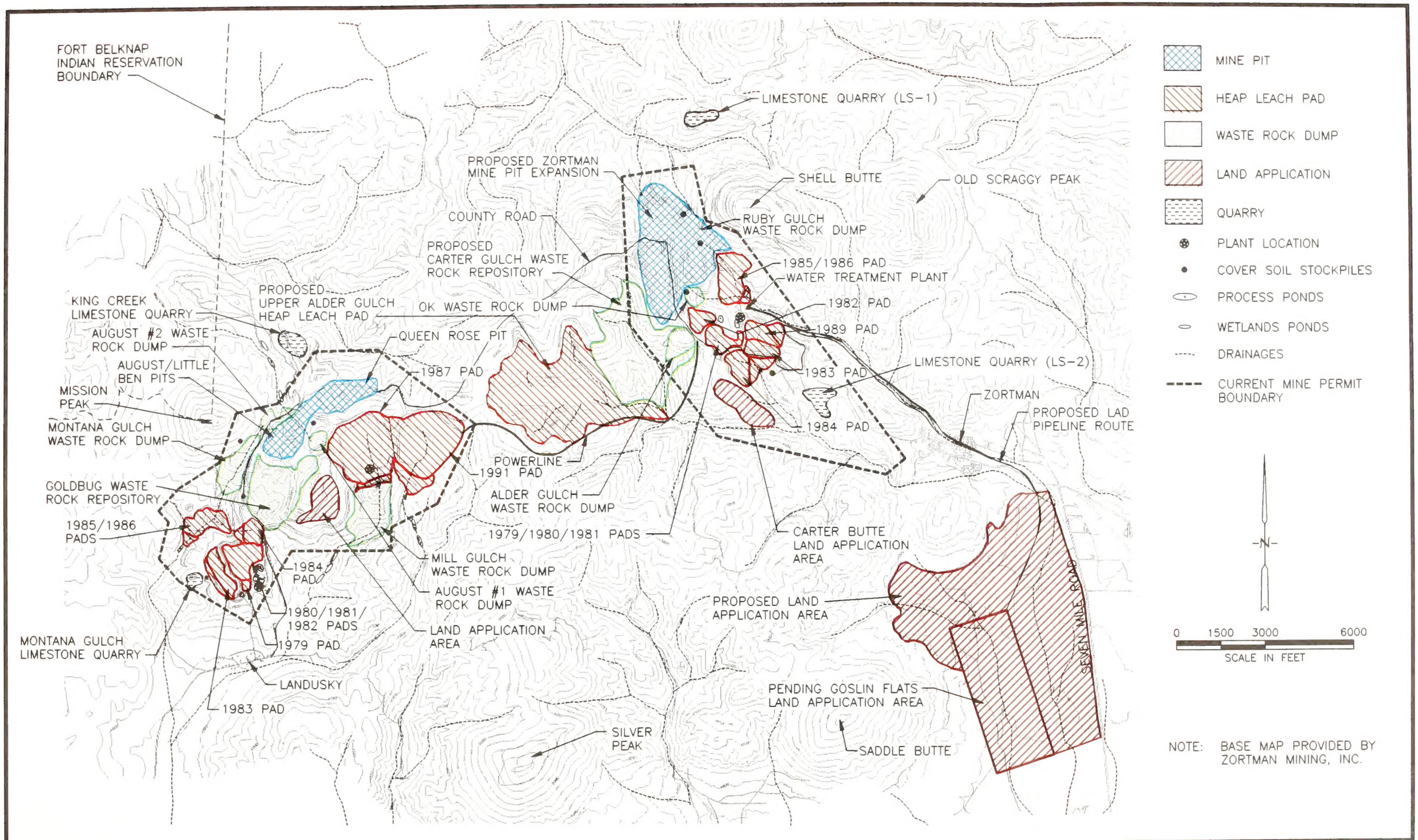
Waste rock would be hauled by truck to the Carter Gulch waste rock repository. Placement of the waste rock within the repository would depend on the material's potential to create acid drainage. Waste rock would be segregated within the waste rock repository on the basis of total sulfur content, as shown in Table 2.8-6 of Alternative 4. However, waste rock could not be used in the construction of reclamation covers based solely on the sulfur content of the rock. Material used in construction purposes and as a capillary break must meet the geochemical and lithologic criteria described in Section 2.9.2.

2.9.1.2 Crushing Operation

Metallurgical testing at Zortman has shown that unoxidized ore must be crushed to facilitate gold recovery. Crushing reduces the size of individual ore fragments, thereby increasing the surface area upon which the heap leach chemicals will act to separate gold from the rock matrix. The basic process employed under this alternative for ore crushing would not change from that described in Alternative 4, Section 2.8.1.2. However, the location for the crushing operations would be modified.

Because this alternative calls for placement of the ore heap leach facility in Upper Alder Gulch, an ore conveyance system would not be constructed along Alder Gulch and no ore processing facilities would be sited on Goslin Flats. Therefore, all ore crushing operations would take place in the vicinity of the pit complex, at a location selected by ZMI based on area requirements and ease of access. Ore would be hauled from the mine pit in trucks and placed in a truck dump hopper located at the crushing area near the pit. In the event the hopper is inoperable, the ore would be placed in a stockpile adjacent to the primary crusher. Oxide ore would be crushed to less than 6 inches in diameter by a primary crusher, then dumped or trucked to a mixed ore (both oxidized and unoxidized ore) stockpile. Unoxidized ore would also be processed through the primary crusher, and then would pass through additional crushing mechanisms in an enclosed facility.

Unoxidized ore would be placed in a coarse ore stockpile and fed into the secondary and tertiary crushing mechanisms. These crushers would be located in two buildings connected by conveyors. The secondary and tertiary crushers would operate continuously with a



<u>ALTERNATIVE 5:</u> MAJOR NEW FACILITIES INCLUDE THE UPPER ALDER GULCH HEAP LEACH PAD, THE CARTER GULCH WASTE ROCK REPOSITORY, AND THE ZORTMAN MINE PIT EXPANSION

ALTERNATIVE 5
ZORTMAN–LANDUSKY EXISTING AND PROPOSED FACILITY LOCATIONS

FIG. 2.9–1

ZLF–ALT5

pass-through rate of approximately 1,000 tons/hour, although up to 2,000 tons/hour could be processed if necessary. The crushed, unoxidized ore coming out of the tertiary crusher would be fed into either the mixed ore stockpile or placed in a third stockpile containing only crushed, unoxidized ore. Three ore stockpiles would be developed and placed either near the pit complex or in closer proximity to the leach pad in Upper Alder Gulch. The contents of the three ore stockpiles were described in Alternative 4, Section 2.8.1.2.

Mining of the deeper portions of the Queen Rose/Suprise, August/Little Ben, or South Gold Bug pits at the Landusky Mine would not require crushing or special handling for leaching purposes.

2.9.1.3 Conveyor System

Because no ore processing facilities would be located in Goslin Flats, a conveyor system would not be constructed under this alternative. Ore would be transported from the crushing facilities to the leach pad by haul truck.

2.9.1.4 Upper Alder Gulch Heap Leach Pad

The heap leach pad and adjacent facilities, shown on Figure 2.9-2, would cover approximately 180 acres situated in the Alder Gulch drainage. Surface water diversion canals would direct natural flows around the leaching facility to Alder Gulch below the leach pad and appurtenant structures. An area of approximately 308 acres is enclosed by the proposed drainage canal. The leach pad would be approximately 4,000 feet long by 3,000 feet wide, and sized to contain 80 million tons of ore, the presently anticipated reserves. The heap leach pad liner design includes a composite liner system consisting of layers of compacted clay, a synthetic PVC membrane, and a protective layer of crushed rock, tailing from historic ore milling, or rock crushed sufficiently to reduce sharp angles to minimize potential puncturing of the PVC. Ore would be stacked in 25-foot lifts to a maximum depth of approximately 550 feet.

The Alder Gulch heap leach pad is designed as a valley fill leach pad. The ore heap would be placed on the pad in lifts at a 3H:1V slope behind the starter dike. The 3H:1V constructed slope would also serve as the reclaimed slope. Benches would be constructed every 100 vertical feet for access to the ore heap from the valley sides. The proposed pad would incorporate in-heap impoundment of solution behind a starter dike to reduce pond costs and to aid cold weather operation. As shown on Figure 2.9-3, the leach pad design includes a composite liner and a 50-foot high starter dike with gate controlled outlet pipes to allow gravity flow of solution to the processing and contingency ponds. The starter dike would allow solution to be impounded behind the embankment and in the heap. A surge capacity of about 9 million gallons of solution would be available as in-heap impoundment. An operational head (hydrostatic pressure) of about 20 feet would be maintained on the liner at the starter dike during normal operations. The system could handle a maximum of 50 feet of head.

The perimeter of the pad and process area would be fenced with Page wire (similar to field fence, a 9 to 12 gauge woven wire). These fences would have 7.5-feet-high steel posts and 8-foot set posts 6 inches in diameter. All posts would be placed 15 feet apart and the Page wire reaches 6 feet high. The pad and process area perimeter would be fenced, as well as the ponds within the perimeter to ensure wildlife protection.

Leach Pad Construction

The following sections describe the construction and operation of the heap leach pad and how leaching solution is processed.

Foundation - All cover soil displaced during construction of the heap leach pad in Upper Alder Gulch would be picked up and stockpiled separately, one for topsoil, the other for subsoil. The subsurface would be regraded to create a stable foundation surface and to ensure effective leach solution drainage from the valley side slopes to the pregnant pond. Materials considered unsuitable for the pad foundation, such as wet, frozen, or soft soil, would be excavated and stockpiled. Compacted fill would be required in some areas of the leach pad foundation to attain the desired grades. In addition, some areas of the valley may need to be graded or cut and filled to flatten slopes to an acceptable grade for liner installation. Pad construction would begin at the base of the starter dike, extend down the upstream slope of the starter dike, and continue up the valley as needed for ore placement. Compacted fill would be placed in loose lifts of 8 inches and compacted to at least 95 percent of the Standard Proctor laboratory dry density, a standard unit of measurement employed to maintain quality control as construction progresses. A layer of gravel or crushed, non-acid forming rock would be placed in the bottom of the valley below the leach pad liner, starter dike, and ponds to convey seepage away from the liner. The gravel layer would also be used as a leak detection system to detect leaks through the liner. Runoff between the proposed

drainage diversion canal and intermediate limits of the liner would be directed into the gravel underdrain and leak detection system by an intermediate drainage control berm.

Liner - The pad liner system would consist of approximately 12 inches of compacted clay, mined from the Seaford clay pit, overlain by a textured, 30-mil PVC geomembrane. PVC would be used for the synthetic liner for several reasons. First, ZMI has used this material at other facilities at the Zortman and Landusky mines. PVC is more flexible and easier to install than some other synthetics, such as HDPE. Also, PVC often requires fewer seams. This is important because seams are the most likely source of leaks. In addition, PVC is an accepted industry standard for this application.

Approximately 300,000 yd^3, or 500,000 tons, of clay would ultimately be required for liner construction. The clay would be placed in 6-inch loose lifts and compacted to at least 95 percent of the Standard Proctor laboratory dry density. A cross-section of the liner system is shown on Figure 2.9-3. Clay would be hauled approximately 7.5 miles from the Seaford pit to Upper Alder Gulch using ZMI trucks or a contractor fleet. Clay hauled to the leach pad would require transport through Zortman. Trucks would be grouped at the clay pit and travel as a convoy under the direction of front and rear pilot vehicles.

A geosynthetic fabric would be placed on the PVC liner for protection from tears and punctures during placement of the gravel layer. A minimum of 18 inches of 1-inch or smaller crushed rock would be placed on the geosynthetic fabric to protect it from potential punctures and tears during ore placement operations, and to provide an effective drainage horizon for solution transfer to the solution collection system. Alternatively, a graded protective layer could be used if well-rounded rock is not readily available. Six inches of rounded material or salvaged tailing could be placed on the geosynthetic fabric below 12 inches of crushed material. This upper layer could consist of select, competent ore or waste rock which has been crushed and screened to less than ¾ inch size. No greater than 7 percent of the material would be silt or clay sized particles.

Ponds - The pregnant, barren, and contingency pond would be constructed by balanced cut and fill methods. Interior and exterior side slopes would be 2.5H:1V. An underdrain system would be installed to direct groundwater away from the ponds. Fill material would be placed and compacted in lifts and a 12-inch layer of compacted clay placed over the interior. A synthetic liner, consisting of 60-mil HDPE, would be placed over the clay. Even though HDPE has a higher cost than other synthetic materials, it would be used for synthetic liners in the ponds for a few reasons. First, it has been demonstrated as an accepted industry standard for this application. Second, HDPE is not susceptible to ultraviolet radiation, as is PVC, and will therefore not photodegrade. This is important because the pond liners would be subjected to ultraviolet exposure.

The pregnant and barren ponds would each hold approximately 6 million gallons of solution. The contingency pond would be sized to hold the calculated leach pad surcharge from a 6.33-inch, 24-hour precipitation event plus the 36-hour draindown of the leach pad in the event power was lost during the storm event. Therefore, the contingency pond would hold approximately 38 million gallons in storage. All solution ponds would be enclosed with 8-foot fencing capable of excluding big game and other large animals from potentially contaminated water.

Construction Quality Control - Construction of the heap leach pad would begin near the starter dike section of the leach pad (the "head") and proceed up the valley to the extent of the ultimate design. ZMI would retain a professional engineer or engineering company as an independent inspector to monitor leach pad construction. This inspector would be responsible for monitoring and reporting on all phases of construction to assure that design specifications are met, and that field modifications are justified and summarized. The inspector would perform or oversee material inspections and compaction tests, including tests on fill material and the soil liner, permeability tests on the soil liner, strength tests of the soil liner, and grain size analysis of solution drain material. The inspector would also prepare daily reports. An as-built report and drawings of the facility would be submitted to the agencies for review.

An independent third-party engineering firm would monitor and oversee installation of the synthetic liner, including deployment of the liner to the site. Liner panels would have a minimum overlap of 6 inches and be welded together with an adhesive-bodied solvent on a clean seaming surface. All field seams would be tested using a 30-psi air lance along the entire seam. Where air pockets or riffles are observed, they would be marked, repaired, and air lanced again to ensure proper bonding. The entire liner area would be inspected. Wrinkles, punctures, or defects that may be detected would be repaired and tested in order to ensure proper bonding. Additionally, seam analysis samples would be collected and sent to a certified laboratory for peel adhesion and bonded seam strength (shear) to confirm

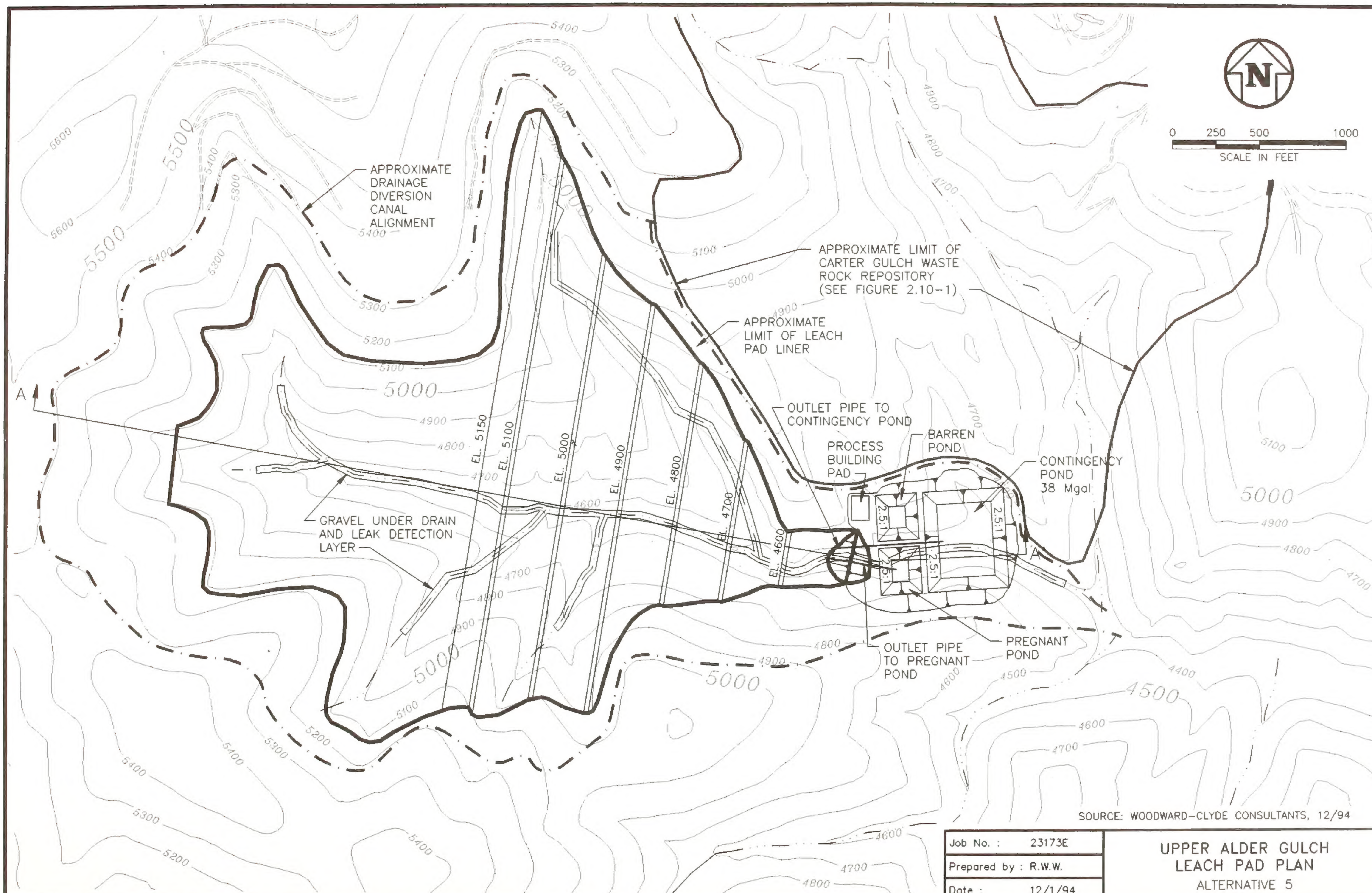


FIG. 2.9-2

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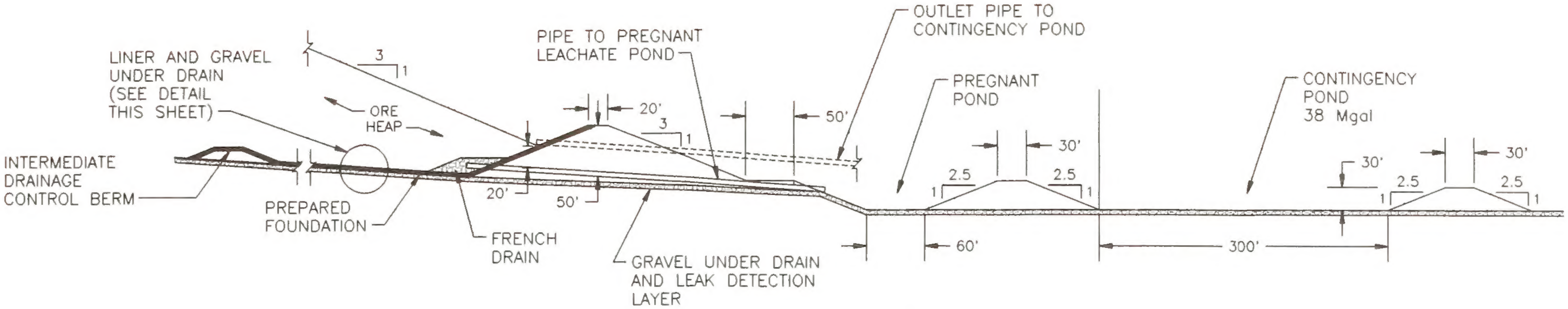
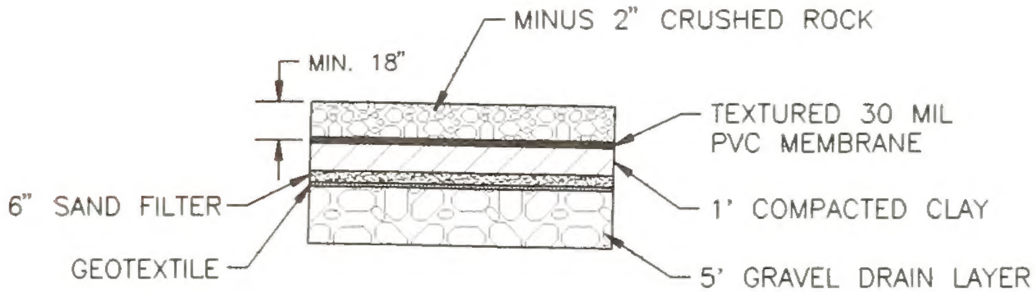


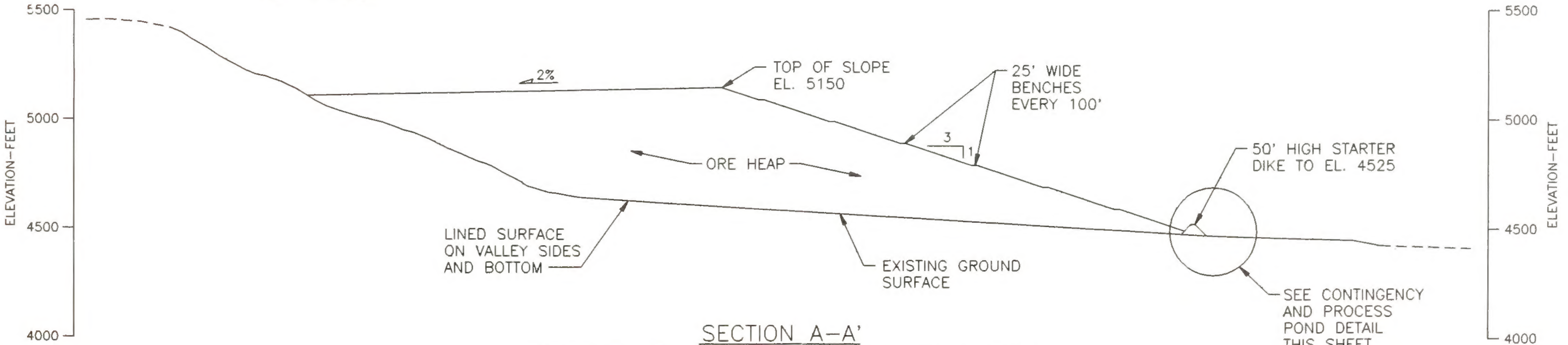
CONTINGENCY AND PROCESS POND DETAIL

NOT TO SCALE



LINER AND UNDER DRAIN DETAIL

NOT TO SCALE



SECTION A–A'

PROFILE OF VALLEY FILL HEAP LEACH PAD

SCALE: 1"=500'

SOURCE: WOODWARD CLYDE CONSULTANTS, 12/94

Job No. :	23173E	UPPER ALDER GULCH LEACH PAD PROFILE AND DETAILS ALTERNATIVE 5
Prepared by :	R.W.W.	
Date :	12/1/94	

3173BWPR

FIG. 2.9–3

field testing and observation. An as-built report and drawings of the facility would be submitted to the agencies for review.

Leach Pad Operation

Generally, facility operation at Zortman Mine's Upper Alder Gulch site would include: the leaching of ore stacked on the pad; collection of pregnant solution at the bottom of the heap near the starter dike; transfer of the pregnant solution to ponds for storage prior to metal extraction; the metal extraction process itself; and the storage of barren solution in a pond for re-application to the ore heap.

Leach solution would be sprayed onto the heap at an average application rate of 0.005 gal/min/sq ft. A system of pipes and valves would allow the solution that is retrieved from the ore heap to be redistributed to the heap or sent to the process plant. Ore materials placed on the leach pad would vary from less than ½ inch to less than 6 inches in size. An oxide/non-oxide blend would be leached on the pad with lime added at a rate of approximately 4-8 lbs/ton of ore prior to loading. The mix of ore would typically be approximately 50 percent oxide/non-oxide, although there would be occasions where only oxide or only non-oxide ore would be loaded. Lime addition would increase pH values, enhance ore processing, and speed facility reclamation and closure. Equipment operation on the protective layer above the liner would be restricted to reduce the potential for liner damage.

As described in Alternative 1, Section 2.8.1.4 the 7.6 million tons of ore from the expanded mining operations at Landusky Mine would be taken to the 87/91 leach pad for processing. This leach pad has already been permitted. No new construction of either lined pad area or buttress is required or proposed; expansion of the pad would occur by increasing the vertical loading of ore on the pad. The final pad capacity on this facility would be increased from the current 101.9 million tons to 109.5 million tons, and the final elevation at completion would be 5,450 feet, an increase in elevation of approximately 50 feet. There are no changes in lateral disturbance which are associated with the increase in loading of this pad. (Some lateral disturbance would occur for leach pad reclamation. See Section 2.9.2.)

Solution Management

The volume of solution required for ore processing would be maintained by adding makeup water during dry months, and by temporarily storing solution during periods of higher precipitation. Storm surge solution at the Upper Alder Gulch leach pad would be within the heap, in the pore space of the ore, and behind the starter dike or in surface ponds. The average external makeup water rate is expected to be 140 gallons per minute.

Pond Capacity - The barren and pregnant solution ponds would be sized to store approximately one day's maximum anticipated process plant requirements plus one million gallons contingency. Based on a maximum process flow rate of 3,500 gallons per minute, the barren and pregnant ponds would each be sized to retain about 6 million gallons.

The total in-heap storage capacity is approximately 9 million gallons impounded by the starter dike. The contingency ponds have been sized to store a total of approximately 38 million gallons of solution. In total, the system (barren, pregnant and contingency ponds and starter dike) would have a solution storage capacity of approximately 59 million gallons.

No additional solution ponds are proposed in connection with the proposed additional ore and waste rock mining at Landusky Mine. No change is proposed to the leak detection system, as described in Section 2.5.1.3, Alternative 1. The existing underdrains and monitoring wells that are beneath and adjacent to the Landusky Mine leach pads would be used to monitor for process solution leakage.

Heap Draindown - Heap draindown is the process through which the moisture content of the ore at the time heap leaching is conducted is reduced to an amount which the ore can retain after leaching stops. This reduction in moisture content adds free solution to the system, thereby increasing storage requirements and reducing storage capacity. A certain amount of operational draindown occurs through the heap leaching process, as active leaching advances from one portion of the ore heap to another, thereby isolating some ore from the active leach cycle.

It is possible that a heap leach facility's solution pumps could become inoperable, thereby removing some or all of the ore being leached from the active leach cycle. In such instances, excess solution drains from the ore. This circumstance is known as emergency draindown. Should an emergency draindown occur during the design storm event (6.33-inch, 24-hour), excess solution would accumulate at a rate dependent on the leach pad area. The Upper Alder Gulch leach pad facilities would be designed to accommodate a 36-hour storm and pump shutdown duration.

Processing Plant Operation
At the Zortman Mine, a new ore processing plant with carbon adsorption circuit would be constructed near the base of the heap leach pad, with the contingency and process ponds. This would be more costly than modification of the existing processing plant at the mine site, but it is more efficient and safer for the processing facilities to be sited in one area. The ore processing would occur as described in Alternative 4, Section 2.8.1.4.

No change is proposed in operation of the Landusky Mine processing plant. The existing facilities would continue to be used to process gold bearing solutions from the leach pads. There would be no changes in reagent handling and storage.

Reagent Handling
Because the ore processing plant under this alternative would operate in the same manner as described in the CPA, the use and handling of processing reagents would also be similar. Reagent handling is described in Alternative 4, Section 2.8.1.4.

2.9.1.5 Waste Rock Repositories

Carter Gulch
Prior to construction of the new Carter Gulch waste rock repository, ZMI would remove all of the waste rock, approximately 3.4 million tons, from the existing Alder Gulch Waste Rock Dump. The existing material in Alder Gulch is seeping poor quality water from the toe of the dump, and removal of the material would reduce impacts to the drainage. This material would be relocated to the leach pad at Upper Alder Gulch for further processing as ore.

The proposed waste rock repository would be constructed in Carter Gulch, a fairly steep side drainage to Alder Gulch (see Figure 2.9-1). A portion of Alder Gulch has already been disturbed, although approximately 150 additional acres would be needed to store the waste rock. The waste rock repository would be designed to hold 78 million tons, although ZMI's proposed action would generate approximately 60 million tons. The construction for this facility would be as described in Alternative 4, Section 2.8.1.5.

Gold Bug
As described in Alternative 4, Section 2.8.1.5 about 7 million additional tons of waste rock would be mined and scheduled for disposal in the Gold Bug waste repository or backfilled in the Queen Rose pit at the Landusky Mine. The nominal slope of the repository would be built at 3H:1V, and drainage benches (15 - 30 feet wide) would be placed every 100 vertical feet. Reclamation at the Gold Bug would continue to occur concurrent with mining activities. Section 2.9.2.5 provides more information on the repository reclamation program.

Waste Rock Handling
Alternative 4, Section 2.8.1.1 describes how waste rock would be selectively handled and sorted at the two mines according to their sulfur content and acid neutralization potential. No changes from that strategy are required in this alternative, except that waste rock could not be used in the construction of reclamation covers based solely on the sulfur content of the rock. Material used in construction purposes and as a capillary break must meet the geochemical and lithologic criteria described in Section 2.9.2.

2.9.1.6 Other Features and Facilities

Office/Laboratory Facilities
This alternative would not change the locations or functions of ZMI's office and laboratory facilities. The main office building for ZMI is located in the town of Zortman. The production assay lab is located across the street from the main office in a separate building. The laboratory and office functions would continue as described in Alternative 1, Section 2.5.1.5. No modifications to the CPA are required under this alternative which would affect the Landusky Mine infrastructure and utilities. In fact, the CPA would have little change to the currently permitted conditions as described in Section 2.5.1.5. A summary follows.

Access and Haul Roads
With a couple of exceptions, the road network described in Alternative 4, Section 2.8.1.6 would be developed under this alternative as well. One exception would include construction of ore haul roads to the Upper Alder Gulch heap leach facility. As with other mine haul roads, this road would be constructed to allow a 70-foot running width from the inside edge to the inside toe of the safety berm. The other modification is that roads would not be constructed in Alder Gulch for access to a conveyor system, as ore would be transported to the heap leach pad by truck. All haul roads would be constructed on the daylight edge of the pit, which is the lowest area on the pit perimeter. Haul roads would be left on the remaining daylight edge after the pit is mined. Haul roads would not be needed into Goslin Flats.

A haul road would be constructed in the permitted disturbance area for accessing the South Gold Bug Pit area. Any other access or haul roads would remain or be constructed on existing disturbed areas within the pits. The 2,500 feet of haul road to the King Creek limestone quarry would be widened from 20 to 60 feet, resulting in an additional total disturbance of 5.7 acres.

Power and Water Supply

Power requirements for this alternative do differ from that proposed in Alternative 4 because no facilities would be constructed in Goslin Flats. Power requirements for the mine expansion and ore processing facilities would be supplied by connecting the Landusky Mine power line to the expansion operation. This would allow for any additional power needed at one operation to be allocated from the other.

Water supplies are likely to be similar as described for Alternative 4 in Section 2.8.1.6. Additional water could be required for road dust control since there would be a larger network of haul roads near the mine, and increased truck traffic to transport ore and bring in clay from the Seaford Pit.

No changes are proposed in the current power and water supply systems for the Landusky Mine. Electrical power is obtained from the Landusky grid, which is supplied by the Big Flat Power Cooperative through an existing 23-kV line. Potable water is obtained from groundwater wells. Process water is obtained from precipitation and groundwater appropriation.

Sewage Treatment

No changes are proposed from the current septic waste treatment systems at either mine. See Section 2.5.1.5, Alternative 1, for additional information.

Chemical Use

Chemicals used and required under this alternative would be essentially the same as described in Alternative 4, Section 2.8.1.6 except that ore processing chemicals (for example, sodium cyanide, lime, etc.) would be transported through the town of Zortman up to the processing facilities near the mine site. Increased amounts of diesel fuel above that required under the CPA would be needed since ore would be hauled by truck to the heap leach pad, as opposed to ore transport on a conveyor system.

No changes are proposed from the current inventory and use of potentially hazardous materials at the Landusky Mine. See Alternative 4, Section 2.5.1.7 for additional information.

Waste Disposal

The types and amounts of solid waste generated under this alternative would be as described for Alternative 4 in Section 2.8.1.6, and expanded upon in Section 3.14. Therefore, no changes are proposed from the current disposal methods for solid and/or hazardous wastes at either mine.

2.9.1.7 Water Management

This section presents an overview of water management plans prepared by ZMI, with additional mitigating measures developed by the agencies, to mitigate impacts from existing and proposed expanded mining operations. It includes a description of measures that have been or would be implemented for management of process water, storm water and mine drainage. This section is divided into discussions on surface water runoff control, water capture, water treatment and LAD. Many of the water management measures proposed by ZMI in Alternative 4, Section 2.8.1.7 would apply to this alternative and are not repeated. Additional detail on measures to improve and maintain water quality are contained in the Water Quality Improvement Plan which is presented in Appendix A.

Objective: The objective under this and all other alternatives is to protect beneficial use and to achieve and maintain compliance with water quality standards.

Approach: This alternative relies on a combination of source control and active treatment to protect water quality. Mine waste is segregated and isolated based on acid generating potential. Low permeability reclamation covers are used to limit infiltration of precipitation into mine waste, thereby restricting water contact with potentially acid generating materials. Diversion of runon water is used to prevent stored acidity within the mine waste from being transported into adjacent surface or ground waters. Capture and treatment of impacted waters is required initially and used as a secondary measure in the long-term.

The emphasis is to institute source controls to prevent contact of surface or ground waters with potentially acid generating materials. Reclamation covers which would greatly reduce or perhaps eliminate the need for long-term water collection and treatment are required. The management of mine water requires keeping mine drainage, storm water and process waters segregated so that each can be handled using the technology most appropriate to each water's character.

Additional design measures have been incorporated in this alternative to facilitate water management. The

design criteria for stormwater diversions would be increased to convey runoff from the 6.33-inch, 24-hour storm event with 1-foot of freeboard.

The leach pad facility would be relocated from Goslin Flats to Upper Alder Gulch. This relocation would eliminate the loss of the approximately 1-acre of wetlands in Goslin Gulch. However, increased engineering constraints would be necessary to avoid impacting the non-wetland waters of the U.S. present in Upper Alder Gulch.

Surface Water Runoff Control

With the exception of the Upper Alder Gulch drainage, most surface water runoff control features described in Alternative 4, Section 2.8.1.7 would apply to this alternative. All drainage and diversion ditches would have to be able to pass the peak flow from the 6.33-inch, 24-hour design storm event with 1 foot of freeboard as a safety measure.

Diversion channels would be trapezoidal or V shaped, lined with geotextile to prevent piping and rip-rapped with durable, non-acid forming rock sized for drainage area requirements. All diversion ditches would have road access for maintenance purposes. Maintenance would consist of removal of sediment load and repositioning of rip-rap as required. Sediment would be disposed in the waste rock repository.

Mine Pits - At the Zortman Mine, the above pit diversions, 5,000-foot elevation diversion and pit floor drainage plans would all be constructed as described in Alternative 4 for management of surface water and prevention of groundwater recharge. The only significant difference would be the additional backfilling of the pits with the 85/86 leach pad spent ore, OK waste rock dump, and the excess Ruby Gulch tailings. This would facilitate runoff of surface waters from the mine pits into Ruby Gulch.

At the Landusky Mine, portions of the pit walls that are potentially acid forming and cannot be capped would have diversions installed above the highwalls where access allows. These diversions would route storm water away from the pit highwalls. Diverted highwall runoff would be directed to drain to Montana Gulch, as would any other runoff originating at areas not reclaimed and capped. The diversions would be designed to be maintenance free to the extent possible and pass the peak flow from a 6.33-inch storm event with one foot of freeboard. Highwalls and diversion structures would be visually inspected on a periodic basis and repairs made as necessary.

This alternative requires backfilling of the August/Little Ben pit to the 4,850-foot level, capping of the pit floor, and routing of surface runoff into the King Creek drainage (see Appendix A). The source of backfill would, in part, be the rock fill at the head of the King Creek. The fill removal and pit backfilling would approximately re-establish the pre-mining catchment area for King Creek by reconnecting surface runoff from the August/Little Ben and Queen Rose/Suprise pit areas with that drainage. Settling ponds would be constructed in upper King Creek between monitoring site L-5 and the existing sediment pond used to control erosion of historic mine tailing. The ponds would help prevent water discharged from the reclaimed pit areas from degrading water quality in King Creek. If necessary, this runoff water would be treated prior to discharge to King Creek.

Leach Pads - Diversion ditches constructed around the leach pads to prevent the inflow of storm water would be upgraded to pass runoff from the 6.33-inch, 24-hour storm event.

At the Zortman Mine, the 85/86 leach pad would be detoxified, removed from upper Ruby Gulch, and used to backfill the mine pits or re-leached. Discharges exposed in this drainage would be directed to lined channels and routed to the Ruby Gulch capture ponds for any necessary treatment.

Prior to construction of the Upper Alder Gulch heap leach pad, ZMI would be required to submit a site-specific drainage control plan. The design features for control of surface water at the Upper Alder Gulch heap leach pad would include construction of a surface drainage diversion canal to intercept runoff above the final buildout level. The canal would be sized to convey the design storm runoff event in the drainage basin above the leach pad. The canal would channel runoff water around the leach pad, process areas, and pond and would empty into Alder Gulch below the disturbed area. Until final buildout of the lined area, precipitation that falls on the valley between the drainage diversion canal and intermediate edges of the liner would be channeled into the gravel underdrain by earth berms, to prevent water from seeping under the liner edge. The underdrain would also convey groundwater seepage.

At the Landusky Mine, a drainage trench would be excavated from the side of the west tributary of Montana Gulch that is blocked by the 85/86 leach pad. This would involve excavating approximately 36,000 tons of material with a disturbance of approximately one-quarter acre.

Waste Rock Repositories - At the Zortman Mine, the existing Alder Gulch waste rock dump would be removed prior to construction of the Carter Gulch Waste Rock Repository (as described in Alternative 4). This would remove a current source of contamination from Carter Gulch.

No changes would be made to the present drainage control features for the Gold Bug and Mill Gulch waste repositories at the Landusky Mine. The dump at the head of King Creek would be removed for backfill under this alternative.

Water Capture

Capture systems consisting of ponds, diversions, slurry cut-off walls, and recovery wells would be used to provide for capture of mine drainage to prevent deterioration of water quality in adjacent drainages. Storm water would be segregated from mine drainage. Impacted water would not be released to surface water prior to treatment. Data would be collected in accordance with the monitoring plan to regularly monitor water quality and capture system effectiveness.

No changes would be made to most seepage water capture and treatment systems from those described in the CPA. The Alder Spur capture system would be resized for seepage from the design event. A new capture system would be relocated further downstream to the toe of the Carter Gulch waste repository. A new seepage capture system would be constructed in Upper Alder Gulch below the leach pad dike. All captured seepage water would be pumped to the Zortman water treatment plant for treatment and release into Ruby Gulch.

The existing seepage capture systems at the Landusky Mine would be sized to handle seepage generated by the 6.33-inch, 24-hour storm event. All captured seepage water would be pumped to the new Landusky water treatment plant for treatment and release into Montana Gulch.

As described for the process solution ponds, all seepage capture ponds would be surrounded with 8-foot fencing to reduce wildlife exposure to potentially contaminated waters. Seepage capture ponds and sumps would be inspected on a weekly basis for routine maintenance or repairs, if necessary.

Additional information concerning the capture systems is found in the Water Quality Improvement Plan, Appendix A.

Water Treatment

The location and function of the water treatment plants would remain as described in Alternative 1. ZMI constructed a 2,000-gpm water treatment plant in May 1994 to treat seepage water captured at the toe of existing mine waste rock dumps at the Zortman Mine. The plant operates at a rate of 200 to 2,000 gpm depending on factors such as precipitation amounts and seasonal operating conditions. Another water treatment plant is planned for the Landusky Mine and would be located in the Montana Gulch area. Interim effluent discharge standards from the plant are BAT for mine waters (40 CFR §440.100). Establishment of final effluent limits and outfall points would occur as part of MPDES permit development.

The water treatment plants would continue to operate until final reclamation measures have successfully produced effluent that meets the water quality standards. Under this alternative, the placement of enhanced reclamation covers, long-term capture and treatment may not be necessary to meet water quality objectives in many of the affected drainages. However, it is provided for as a contingency. As water quality meets discharge standards and the appropriate agencies approve of release of the waters, capture ponds, sumps and pumpbacks systems would be dismantled and the sites reclaimed.

Land Application Disposal

As described for the CPA, provisions for land application disposal are required by the regulatory agencies for final heap draindown at mine closure, or in the case of an extreme precipitation event that overwhelms the capacity of the leaching circuit. Most of the discussion in Alternative 4, Section 2.8.1.7 applies to this Alternative.

At the Zortman Mine, a total of 390 acres has been identified as suitable for use as a land application area at Goslin Flats (see Figure 2.8-15). Since a leach pad would not be developed in Goslin Flats under this alternative, the pipeline carrying neutralized process solution would extend from the ore processing facilities down Ruby Gulch to Goslin Flats instead of along the conveyor route as in Alternative 4.

As with Alternative 4, no operational land application disposal is planned as part of this alternative, and no emergency land application should be required during operations. In the event land application is required, it would be conducted as described in Alternative 1, Section 2.5.1.6 for currently permitted operations.

2.9.2 Mitigated Mine Reclamation

The agencies have developed modifications to ZMI's proposed reclamation procedures which would: (1) reduce infiltration into areas with the potential to cause acidic drainage, (2) remove waste rock dumps and other sources currently causing degradation of surface water or groundwater, and (3) implement the Water Quality Improvement Plan to further mitigate effects of ARD should reclamation procedures fail to adequately protect water resources. Many of these reclamation modifications were described in detail in Section 2.7.2, for the Agency Mitigated Reclamation for Alternative 3. However, that alternative describes reclamation actions to be taken if ZMI's proposal for mine expansion is not approved. This alternative describes modified reclamation actions that would take place in conjunction with the mine expansion. The major reclamation modifications to be incorporated in this alternative include:

- Unless specifically identified below, mine waste rock facilities and ore heaps are assumed to be acid generating and would be reclaimed using improved reclamation covers. Cover soil on the facilities would be removed, stockpiled, and reused.

- With the exception of most leach pad dikes, existing facilities would be reclaimed to an overall 3H:1V slope with constructed benches every 100 vertical feet between benches. This measure would reduce erosion and soil loss, increase overall surface reclamation success, and result in more stable facilities. In order to achieve the slope reduction while minimizing additional land disturbance in adjacent drainages, some material may have to be off-loaded from existing facilities and backfilled into the pit.

- To enhance the probability of long-term reclamation success, soil loss from reclaimed areas must be less than 2 tons/acre/year.

- Reclamation Cover C would be modified to include 6 inches of compacted clay (as opposed to 3 inches of compacted clay) between the bottom substrate and the PVC liner. The PVC liner thickness would be increased to 30 mil. For the purpose of discussion in this and future alternatives, this cover will be known as "Modified Reclamation Cover C."

- In order to classify as "Non-Acid Generating" and be used without restriction in construction and reclamation, thereby ensuring the potentially acid generating materials are not placed in areas potentially exposed to surface water and the open atmosphere, waste rock:

  1. Cannot be composed of breccia, felsic gneiss, monzonite, quartzite, or trachyte lithologies;

  2. If amphibolite, mafic gneiss, shale, dolomite or limestone must have a total sulfur content less than or equal to 0.8 percent, and a paste pH of 6.0 or greater;

  3. If syenite, must have a total sulfur content less than or equal to 0.2 percent, a paste pH of 6.5 or greater, and a NNP greater than or equal to 0;

  4. Must meet the criteria above as demonstrated by sampling and analyzing lithologies from every blasthole providing non-acid generating material for total sulfur, Paste pH and NP. All blastholes within a discrete mineable block (25 feet x 25 feet) must meet these criteria.

  5. If syenite, can only be used in reclamation covers and not for fill or other construction.

- To ensure that only NAG materials are used in facilities transporting surface water or seepage water, material used for capillary break/drainage layers may be obtained from the unmineralized sources specified in Section 2.9.2.1.

- Rock underdrains would be built with durable, unmineralized limestone as an additional precaution to buffer acidic drainage.

- No trees would be used in revegetation except on a limited basis for visual impact mitigation. Only grasses, forbs and shrubs would be used to enhance wildlife habitat. Crested wheatgrass could not be used in the reclamation seed mix.

- Vegetative cover must achieve 90 percent of that demonstrated in adjacent, natural communities of similar composition and location to be considered acceptable.

- An expanded monitoring program would be implemented, as described in Section 2.9.3, and reclamation viability would be monitored by ZMI until the agencies have approved final closure and released the mine reclamation bond.

Zortman Mine

- The back-filled pits would be graded so that runoff drains freely, without impoundment in the pit, into the Ruby Gulch drainage.

- The 89 leach pad dike would be tested for sulfur content as described in Section 2.8.2.2, and re-reclaimed if sulfur exceeds 0.5 percent in more than 10 percent of the material tested.

- After detoxification, the Zortman 85/86 leach pad and dike would be removed to create a free draining surface and placed in the pit as backfill material prior to pit floor reclamation.

- The OK waste rock dump and Upper Alder Gulch would be removed and used to backfill the pit complex or leached on the pad. Cover soil would be re-salvaged and the waste rock footprint reclaimed.

- The sulfide storage area in Ruby Gulch would also be removed and placed on the Upper Alder Gulch leach pad for ore processing.

- The tailing in Ruby Gulch above the town of Zortman would be removed from the drainage and placed in the pit complex or used as reclamation or construction material. The drainage would be restored as mitigation for existing disturbance to waters of the United States by other Zortman and Landusky mines facilities.

Landusky Mine

- Rock fill would be removed and used as backfill to raise the pit floor to an elevation of approximately 4,850 feet (at the midpoint of the drainage) or the minimum elevation necessary to create a surface which would freely drain into King Creek. Sources of pit backfill to reach the approximate 4,850-foot level would include the Montana Gulch waste rock dump and the 85/86 heap leach pad.

- The Landusky 91 leach pad dike would be re-reclaimed as appropriate to allow redistribution of spent ore to the south, west and east of the 87/91 pad. This action would eliminate the potential for surface water from the 87/91 pad to runoff north of the mine site into drainages on the Fort Belknap Reservation.

- Existing reclamation covers on the Gold Bug waste rock repository and the Mill Gulch waste rock dump may require supplemental cover soil to meet the performance criterion for limiting infiltration.

- To unblock surface water drainage in the western tributary of Montana Gulch, a drainage channel would be constructed along the west margin of the 85/86 leach pad.

- Highwall runoff would be diverted from the mine pits into Montana Gulch and treated if necessary.

- Contingency water capture systems and settling ponds would be installed in upper King Creek to treat surface water runoff from the backfilled pit floors.

Final reclamation of all Zortman Mine facilities is anticipated to occur within 3 years after the Upper Alder Gulch leach pad has been detoxified and liner perforated. Final reclamation of all Landusky Mine facilities is anticipated to occur within 3 years after the 87/91 leach pad has been detoxified and the liner perforated.

The following sections summarize the specific reclamation plans and actions proposed by ZMI for each of the major disturbance areas, and provide a description of prescribed modifications to the reclamation procedures under this alternative.

2.9.2.1 Reclamation Materials

Reclamation materials would be required for construction and installation of reclamation caps and for use in construction of drains and diversions. The primary materials to be used in reclamation covers would include non-acid forming waste rock and limestone, clays and cover soil. These materials and their sources were described in Alternative 4, Section 2.8.2.1. The following describes only modifications from the CPA.

Non-Acid Forming Material

Non-acid forming materials would be used in reclamation covers on all disturbed areas. The reclamation covers used in this alternative require a capillary break/drainage layer of 36 inches, to be composed of a suitable non-acid generating waste rock or limestone.

Under this alternative, the waste rock must meet the geochemical and lithologic criteria described in the beginning of Section 2.9.2 to be suitable for construction purposes and reclamation covers. It is likely that sufficient waste rock of suitable quality would be available at the Zortman Mine from new mining for use

in reclamation covers and construction, so that limestone would not be required as a capillary break material.

The non-acid forming waste rock would be mined at the Landusky Mine and stockpiled adjacent to the Gold Bug waste repository for use in reclamation. Non-acid forming waste rock is being used as an interim cap on the Mill Gulch waste rock dump and in the Gold Bug waste rock repository, and as a cap on the 91 heap leach pad dike. Waste rock used in these facilities comes from existing stockpiles and that generated by the ongoing mine operation. Significant additional quantities of NAG material would be used in reclamation covers on all mine facilities. Some of this material could come from waste rock generated at the South Gold Bug pit. Approximately 38 million tons of waste rock are now contained within dumps at the Landusky Mine, and it is possible some of this material is not acid generating and could be used in reclamation covers. However, it is only recently that ZMI has begun segregating waste material at the Landusky Mine based on acid generating potential, and it would likely be very inefficient to attempt to separate out suitable waste rock. In addition, the geochemical requirements for waste to be classified as suitable in capillary break are more stringent than the waste handling and segregation strategy ZMI has used.

Limestone

Limestone needed for construction purposes, drainage structures or in reclamation covers would be mined from LS-1, south of Green Mountain (Zortman Mine) or at the King Creek Quarry (Landusky Mine) (see Figure 2.5-2). Mining and haul road development to these sources would occur as described in Alternative 3, Section 2.7.2.1.

Dolomite and limestone from outcrops within the Landusky Mine permit area have recently been used to provide a 3-foot buffering liner across the floor of the 4,640-bench in the Gold Bug waste rock repository. Limestone and dolomite from the mine pits could also be used as capillary break material in the reclamation covers if insufficient quantities of suitable non-acid forming waste rock are available. Alternative 3, Section 2.7.2.1 and Alternative 4, Section 2.8.2.1 provide a description of the activities to be conducted to quarry limestone from the two quarries.

Clay

As described in the CPA (Alternative 4), clay would be used for leach pad liner construction at the Zortman Mine as well as cover material on waste rock repositories, heap leach pads, haul roads, and pit benches and floors to restrict moisture infiltration. Clay required for the Upper Alder Gulch leach pad construction and reclamation would be mined from the Seaford clay pit. ZMI mine trucks or a mine contractor would use Seven Mile Road to haul clay from the Seaford pit to the Zortman Mine facilities (see Figure 2.5-2). Clay used in leach pad construction and reclamation would have to be hauled through the town of Zortman.

Approximately 8.5 acres would be disturbed to supply about 1.1 million yd^3 of clay for Zortman Mine reclamation covers and the leach pad liner.

Clay is used as a component layer of the caps which have been placed on the Mill Gulch waste rock dump and 91 leach pad dike. The expansive clay helps to reduce the possibility of moisture infiltration into the capped facilities. Two six-inch lifts of clay would be used in disturbed areas where Reclamation Cover B is installed, and one 6-inch lift of clay would be used in areas capped by Modified Reclamation Cover C. A 6-inch layer of clay is also used in Reclamation Cover A, to be placed on some haul road disturbances and pit benches. Clay used in Landusky Mine reclamation comes from the Williams clay pit located approximately 2 miles west of the town of Landusky. Up to 9 acres would be disturbed under this alternative to supply clay for reclamation.

Cover Soil

Cover soil at the Zortman Mine is obtained from one of three stockpiles: the 82 leach pad site, the South Ruby Saddle stockpile, or the North Ruby Saddle stockpile. Approximate volumes of soil available at these stockpiles were shown on Table 2.5-9. These stockpiles would probably have insufficient supplies to adequately cover all disturbances to the extent required under this alternative. Approximately 410,000 yd^3 of cover soil would be required. Some cover soil may be salvaged during preparation of the Upper Alder Gulch leach pad, but surveys in this area indicate there is little suitable cover soil available. Another source of cover soil is the material salvaged during re-reclamation activities on facilities which have already been cover soiled and revegetated. Other materials used in reclamation include unconsolidated rock, scree and soil above and below roadway cuts, which are incorporated into the regrading of haul and access roads. It is possible that cover soil for Zortman Mine reclamation would have to

be supplemented with cover soil from the Landusky mine stockpiles.

Cover soil would be used on top of all mine disturbances, either as a final lift on the reclamation caps or as 8-inch layers directly overlying disturbed zones which are determined by testing not to have significant acid generating potential. Cover soil at the Landusky Mine is obtained from one of four topsoil storage areas: the Mill Gulch stockpile, part of the Mill Gulch waste rock dump; the Little Ben soil stockpile; the Gold Bug soil stockpile; and the Montana Gulch soil stockpile. Approximate volumes of soil available at these stockpiles are shown on Table 2.5-10. Other, similar materials used for reclamation purposes would include unconsolidated rock, scree and soil above and below roadway cuts, which are incorporated into the regrading of haul and access roads.

2.9.2.2 Reclamation Covers

Under this alternative, all disturbed areas not being used as pit backfill (with the exceptions noted such as haul roads and building-type facilities, and the 89 leach pad dike) are assumed to be acid generating and would be capped using either Reclamation Cover B or Modified Reclamation Cover C, depending on the slope of the disturbance. Reclamation Cover C would be modified from the CPA by increasing the clay layer to a compacted minimum of 6 inches thick. The PVC liner thickness would be increased to 30 mil. A geofabric would be installed between the soil cover and the capillary break.

The other modification to reclamation covers is in the definition of "NAG" material. The criteria for material to be suitable for use in capillary break were described at the beginning of this alternative description. Certain rock types would be excluded from use and those not excluded must demonstrate a sufficiently high Paste pH, sufficiently low sulfur content, and appropriate neutralization potential. All waste rock considered for use as NAG material must come from blastholes which have been characterized according to these criteria.

The interim covers already constructed on the Mill Gulch and Gold Bug waste rock facilities would remain as permanent reclamation caps, provided that the infiltration performance criteria are met. Additional soil could be added to these covers to achieve water infiltration criteria that the agencies stipulate.

2.9.2.3 Mine Pit Reclamation

Zortman Mine pit reclamation would occur generally as described in Alternative 4, Section 2.8.2.3 with some modification concerning the source of pit backfill materials. Approximately 9 million tons of spent ore and tailing from the 85/86 leach pad and dike, and Ruby Gulch drainage, would be placed in the pit complex as backfill in addition to the approximately 6 million tons of scheduled backfill proposed by ZMI. This material would be used to raise the pit floor to an elevation necessary to freely drain the pit and prevent surface water from ponding and infiltrating through the pit floor. The final pit elevation would be at least 4,900 feet msl. If needed, additional backfill material could come from the Carter Gulch waste rock repository. The final pit construction would be as described in the CPA. The final pit floor would be capped with Reclamation Cover B. The final cover would be revegetated with native grasses and forbs. Pit walls not covered by backfill would be cover-soiled and revegetated where possible, to include tree planting to reduce visual impacts of highwalls.

The Landusky Mine pit reclamation procedures described in Alternative 4, Section 2.8.2.3 are generally those required under this alternative with modifications as follows. The final pit floor elevation prior to backfill proposed for the Queen Rose/Suprise pit is 4,600 feet and the August/Little Ben pit final floor elevation is 4,400 feet. The pits are to be backfilled to a minimum elevation of 4,850 feet in order to create a surface which would freely drain into King Creek. This requirement also necessitates that the source of some of the pit backfill come from the rock fill located at the head of King Creek. Fill removal from the head of King Creek and partial backfilling of the mine pits would help to re-establish the pre-mining catchment area for King Creek. This action would also reduce the potential for surface water infiltrating the pit floors to contact sulfide-bearing zones and create acidic drainage. Pit floors and pit walls would be reclaimed as described in Alternative 3, Section 2.7.2.3.

2.9.2.4 Leach Pad Reclamation

Tasks associated with the reclamation of the heap leach facilities include heap detoxification, surface reclamation including slope reduction, reclamation cover placement, cover soiling and revegetation, and liner perforation. These steps have been described in detail previously.

The following sections summarize the heap leach pad reclamation process from Section 2.8.2.4 with emphasis on modifications required by the agencies.

Existing Heap Leach Pads
The Zortman 85/86 heap leach pad and dike would be removed and placed as backfill into the Zortman pit complex. The footprints from this facility would be tested on 100-foot centers. Those areas with total sulfur content greater than 0.5 percent sulfur would be capped with Reclamation Cover A and revegetated. Areas with lower sulfur contents would be scarified, covered with 8 inches of soil and revegetated.

Heap Detoxification
Heap detoxification for this alternative would be similar to that described in Alternative 1, Section 2.5.2.4. In summary, the spent ore on the leach pad would be rinsed repeatedly with cyanide-free water to enhance degradation of cyanide compounds left in the heap. Heap detoxification is discontinued when the solutions returning from the heap maintain less than 0.22 mg/l cyanide (measured as WAD cyanide) for a six month period which includes a spring, high-flow surface runoff event. Heap solutions remaining after detoxification would be pumped to a containment pond for neutralization and later land application disposal.

Surface Reclamation
The reclamation criterion for pad slopes under this alternative is a 3H:1V slope, if topography allows, but no greater than 2.5H:1V. Constructed benches must be placed every 200 feet of slope length. Slope reduction would be performed by track mounted bulldozers pushing ore heap material from the facility crest or top down over the lift slopes, using cut and fill material from each of the heap benches to obtain the desired slope. Leach pad crests, top and slopes would be capped with Reclamation Cover B (on slopes greater than 5 percent) or Modified C (on slopes 5 percent or less).

Heap retaining dikes would be reduced to a nominal slope of 2.5H:1V, or sufficient to allow placement and retention of Reclamation Cover B. The dike faces would be capped with Reclamation Cover B and revegetated to blend with existing undisturbed contact zones and reestablish vegetation communities. The reclaimed pad surfaces would be revegetated with native prairie grasses, forbs and shrubs to complete final reclamation. In order to help mitigate the visual appearance of the reclaimed heap, portions of the uppermost lift(s) of ore would be varied in thickness and location to create a variable skyline. In addition, "micro-habitat" areas would be created by scouring small depressions with earth-moving equipment during final regrading.

Liner Perforation
The heap leach pad liner system would be perforated after pad detoxification and surface reclamation to eliminate moisture storage and any undesirable hydraulic conditions associated with the reclaimed facility. The liner perforation requirements described in Alternative 3, Section 2.7.2.4 including annual and monthly monitoring, would apply to this alternative. Drain holes would be drilled through the Upper Alder Gulch leach pad's synthetic and clay liner systems to facilitate drainage.

The Landusky Mine 87/91 heap leach pad liner system would be perforated after pad detoxification and surface reclamation to eliminate moisture storage and any undesirable hydraulic conditions associated with the reclaimed facility. The liner would not be perforated until monitoring of the heap effluent indicates that water quality compliance has been met and risk of the formation of acid drainage is established to be minimal.

2.9.2.5 Waste Rock Facilities Reclamation

Carter Gulch Waste Rock Repository
The Carter Gulch waste rock repository would be reclaimed concurrent with construction activities as described in Alternative 4, Section 2.8.2.5. Under this alternative the final slope of the repository would be 3H:1V, and constructed benches must be placed every 200 feet of slope length.

Existing Waste Rock Dumps
At the Zortman Mine, the Alder dump and Ruby sulfide stockpile would be moved to the leach pad. The OK dump would be removed entirely and used as backfill in the pit complex. The remainder of the Ruby Gulch dump (after sulfide stockpile removal) would be leached, if testing demonstrates economically recoverable amounts of metals are present, or backfilled in the pit complex. Cover soil from this dump would be salvaged. The footprint from all of these facilities would be tested for total sulfur content on 100-foot centers. Those areas with total sulfur content greater than 0.5 percent sulfur would be capped with Reclamation Cover A and revegetated. Areas with lower sulfur contents would be scarified, covered with 8 inches of soil and revegetated.

At the Landusky Mine, part of the Montana Gulch waste rock dump could be used as pit backfill. The remaining footprint or unexcavated dump surface would be tested and reclaimed with Reclamation Cover A if sulfur concentrations exceed 0.5 percent. If the dump is not entirely removed that portion remaining would be reclaimed using Reclamation Covers B or Modified C. The interim cap placed on the Mill Gulch and Gold Bug waste rock facilities would remain as a permanent cover. Modified Reclamation Cover C would continue to be used on the Gold Bug waste rock repository. Reclaimed surfaces would be revegetated in accordance with the procedures described in Alternative 4, Section 2.8.2.8 except where modified as described in Alternative 3, Section 2.7.2.8.

2.9.2.6 Support Facilities Reclamation

Unless otherwise noted in the following sections, reclamation of support facilities would be as described in Alternative 3, Section 2.7.2.6 or in Alternative 4, Section 2.8.2.6.

Solution/Process Ponds Reclamation

Reclamation of solution and process ponds would not differ from that described in the CPA (Section 2.8.2.6).

Process Plant Site Reclamation

Final reclamation would include the removal of all structures and equipment used in the mining and processing of ore through heap leach operations. Reclamation of these facilities and footprints would not differ from that described in the CPA, Section 2.8.2.6.

Soil Stockpile Reclamation

Cover soil stockpiles at the mines may be depleted by the time surface reclamation activities are completed. The footprints from the soil stockpiles would be tested on 100-foot centers. Those areas with total sulfur content greater than 0.5 percent sulfur would be covered with 6 inches of clay, followed by 8 inches of cover soil and revegetated. Areas with lower sulfur contents would be scarified, covered with 8 inches of soil and revegetated.

Access and Haul Roads

Reclamation requirements for access and haul roads for both mines would be as described in Alternative 4, Section 2.8.2.6.

Limestone Quarries

Up to 14 acres would be disturbed at the LS-1 limestone quarry to provide about 1 million tons of limestone for construction and reclamation at the Zortman Mine. The ultimate facilities development topography of the limestone quarry and reclamation procedures would be as described in Alternative 4, Section 2.8.2.6.

Up to 3 acres would be disturbed at the King Creek limestone quarry to provide reclamation materials for the Landusky Mine. The ultimate facilities development topography of the limestone quarry would be as described in Alternative 4, Section 2.8.2.6.

Clay Pits

New and old disturbances at the clay pits would undergo reclamation as described in Alternative 4, Section 2.8.2.6. All areas would be revegetated as described in Section 2.8.2.8.

Land Application Area

Following completion of all land application operations, the land application areas would be reclaimed as described in Alternative 4, Section 2.8.2.6.

2.9.2.7 Reclamation Quality Control

ZMI or a mine contractor would place the clay cap used in reclamation covers. This process would be monitored by a qualified, independent third-party engineering firm.

The clay cover would be composed of a clay soil, hauled from the Seaford clay pit, with an in-place compacted permeability of $1x10^{-7}$ cm/sec. This would be accomplished using the following specifications. A test fill would be constructed to establish construction procedures and measure the performance and proper ties of the compacted clay. If the permeability requirement is not met in a test fill at the time of reclamation, then the specifications would be modified to accomplish this requirement. The final specification would be proved in a certified laboratory prior to adoption.

The clay soil would classify as CL, SC, or CH according to the Unified Classification System, ASTM D2487, and meet the following requirements:

- Passing a No. 200 sieve — 20 percent minimum
- Larger than a No. 4 sieve — 10 percent maximum
- Maximum size — 2 inches
- Plasticity index — PI = 10 or greater

The clay soil would be placed as follows:

- Moisture content (ASTM D698), Optimum -1 percent to +3 percent

- Lift loose thickness = 8 inches maximum (6 inches compacted)

- Density after compaction (ASTM D698), 95 percent minimum

- The clay would be pre-moistened in a borrow or thoroughly mixed after placement with appropriate equipment such that all moisture contents fall within the above range. There would be no frozen or deleterious materials and placement would not occur when the ground temperature or air temperature is below freezing.

- The surface on which the fill is to be placed would be compacted to produce a firm foundation. Each lift of fill would be compacted with a sheepsfoot roller weighing not less than 40,000 pounds, or equipment of equivalent weight, which would leave a rough surface to provide bonding between lifts. For Modified Reclamation Cover C, placement would be horizontal lifts. In other words, placement of this cover on slopes steeper than 5 percent would not be permitted. Placement of Reclamation Cover B would be carefully controlled to obtain maximum compaction.

- The top clay lift would be rolled smooth after compaction is completed, using a rubber tired and/or steel wheeled roller. This lift would be covered immediately to prevent desiccation.

Placement testing would include the following:

Test Type	Designation	Frequency of Tests/Cu.Yd
Fines Content	ASTM D1140	1/5000
Particle Size	ASTM D422	1/5000
Plasticity Index	ASTM D4318	1/5000
Water Content	ASTM D4643, 2216, or 3017	1/5000
Density Sand Cone	ASTM D1556	1/2000
Density Nuclear[1]	ASTM D2922	1/2000
Standard Proctor	ASTM D698	1/5000

[1] Nuclear method could be used as an alternate test method for up to 80 percent of the required tests.

Installation of the 30-mil synthetic liner used in Modified Reclamation Cover C would also be monitored by a third-party inspector. Seams would be air-lanced to ensure a good bond was achieved between field seamed PVC sheets. Areas having inadequate bonding, cuts or punctures would be repaired and tested until passed by the third party inspector. The entire area would be visually inspected and passed prior to cover with geotextile.

2.9.2.8 Revegetation Procedures

Revegetation procedures for this alternative would not be expected to differ significantly from those presented in Alternative 4, Section 2.8.2.8. However, no trees would be used in revegetation unless specifically needed to mitigate visual impacts. Only grasses, forbs and shrubs would be used to enhance wildlife habitat. Another change is that crested wheatgrass would not be used in the reclamation seed mix. Areas disturbed at the Zortman Mine are and would be revegetated to stabilize soil and slopes, reestablish communities ecologically comparable to pre-mine conditions, and restore watershed, wildlife, recreational and aesthetic values that meet post-operation land use objectives. Vegetative cover must achieve 90 percent of that demonstrated in adjacent, natural communities of similar composition and location. Stock grazing would be restricted in revegetated areas until the vegetation canopy is 90 percent or greater of the reference area.

2.9.3 Monitoring Programs and Research Studies

The monitoring programs and research studies outlined in Alternatives 1 and 4, Sections 2.5.3 and 2.8.3, respectively would apply to this alternative. A reclamation monitoring program would be instituted to provide ongoing evaluation of surface reclamation viability.

2.9.3.1 Water Resources

The monitoring program for groundwater and surface water would continue as described in Alternatives 1 and 4. Some monitoring wells or surface water monitoring sites could be relocated as a result of actions taken to reduce slopes of heap leach facilities and waste rock dumps. All monitoring required by the water quality

compliance program would be incorporated into this alternative.

In addition, ZMI would be required to establish a monitoring program for operation and maintenance of land application disposal areas. This program, to be submitted to the agencies for review and approval prior to land application of spent solutions, would include at a minimum the following elements:

- Analysis of barren solution samples prior to land application and during, to determine optimum hydrogen peroxide rates and metals loading to soil.
- Installation of suction lysimeters at varying depths with the land application area.
- Collection of pore water samples (from lysimeters) and chemical analysis to include at least cyanide, arsenic, cadmium, copper, selenium, zinc, and lead.
- Daily or more frequent monitoring of land application operations by mine personnel to check for runoff from the area, or new groundwater seeps.
- Immediate sampling of all new seeps or discharges, or solutions found discharging from the area, and analysis for metals and cyanide.

Should any discharges from the area be detected, in the form of solution runoff or new seeps, all land application procedures would be stopped. The agencies must be informed immediately of any such occurrence and approve corrective measures prior to re-start of land application.

The expanded network of monitoring wells and surface water monitoring locations described in Section 2.7.3.1 is incorporated into this alternative. In addition to the monitoring wells described in Alternative 3, a paired bedrock/alluvial monitoring well system would be installed at the toe of the new Zortman Mine waste rock facility in Upper Alder Gulch. The monitoring frequency and analytes for all monitoring locations would also be as described in Section 2.7.3.1.

2.9.3.2 Reclamation Surface Performance Study

Some expansion of the reclamation surface performance study would result from implementation of this alternative. ZMI would be required to monitor seepage from waste rock facilities on a frequency sufficient to develop long-term hydrographs for each site. The hydrographs would be used to assess and predict how and when seepage responds to high flow seasons or storm events. The hydrographs will also provide a tool for predicting opportunistic sampling events to evaluate changes in seepage quality.

2.9.3.3 Surface Reclamation Monitoring Programs

ZMI would implement a program to monitor long term viability of surface reclamation until such time as the agencies release the Mine Reclamation Bond. The program must evaluate the continued performance of such features as:

- Reclamation covers
- Revegetation success and permanence
- Erosion control measures

The reclaimed facilities would be monitored for excessive erosion including rilling and gullying. Excessive erosion would be that level which endangers the overall efficacy of the reclamation features and could hinder the achievement of reclamation goals or environmental compliance requirements. Soil loss could not exceed 2 tons per acre per year. ZMI would be required to notify the agencies of such concerns with the reclamation systems, and propose and implement approved corrective measures to alleviate concerns.

ZMI would be required to submit a surface reclamation monitoring plan to the agencies for review and approval.

2.9.3.4 Other Monitoring Programs

No changes are anticipated to the remainder of the monitoring programs from the descriptions provided in Section 2.8.3.

2.9.4 Reasonably Foreseeable Future Actions

2.9.4.1 Powerline

An upgraded, 69 kV powerline as described in Alternative 4, Section 2.8.4.1 is reasonably foreseeable development for this alternative. The only modification from that description is that the powerline would not end at Goslin Flats but continue up to mine facilities through the town of Zortman.

2.9.4.2 Mine Activities

Foreseeable mine activities for the Zortman Mine would be similar to those described under Alternative 4, as described in Section 2.8.4.2, but development of the estimated 2-million ton ore deposit in the Pony Gulch area is not foreseeable. Since there would not be a conveyor system passing near this deposit it is unlikely it would be proposed for mining.

Since Alternative 5 is almost identical with respect to proposed mining at the Landusky Mine, foreseeable activities under this alternative are the same as previously described for Alternative 4, as described in Section 2.8.4.2. These developments include additional ore extraction from the existing pits, generation of a significant amount of waste rock as new ore is mined, construction and operation of a new leach pad in the Queen Rose pit or at an alternate site, and the construction and operation of new or expanded water treatment facilities would be foreseeable.

2.9.4.3 Exploration Activities

It is anticipated that exploration proposals would be the same as described for Alternative 4 in Section 2.8.4.3. The additional 200,000 linear feet of road and trench construction, with 600 drillsites, over a 10-year period could be proposed. The only difference would be that mineralized areas near the Upper Alder Gulch leach pad would probably be targeted for exploration in order to locate mineable deposits within economic haul distance of the leach pad site.

2.10 ALTERNATIVE 6: MITIGATED EXPANSION AND RECLAMATION WITH WASTE ROCK REPOSITORY LOCATED ON RUBY FLATS RATHER THAN IN CARTER GULCH

Alternative 6 would allow expansion of both the Zortman and Landusky mines but impose agency-developed mitigations on the expansion and reclamation activities. The major modification to ZMI's expansion plans (see Alternative 4, Section 2.8) would be at the Zortman Mine where the proposed waste rock repository in Carter Gulch would instead be placed on the Ruby Flats, just east of the Goslin Flats leach pad. The agencies developed this alternative because a repository on Ruby Flats site would be easier to construct and maintain than would a facility in the steep Carter Gulch drainage. In addition, water quality degradation would be easier to prevent, contain, and correct on Ruby Flats than at the Carter Gulch drainage. The conveyor system would be used for waste rock movement as well as ore transport. A significant modification of the Landusky reclamation requirements would be for ZMI to excavate a drainage notch between the August Pit and Montana Gulch to prevent runoff from the pits from flowing into the August tunnel. Other mitigating measures are incorporated into this alternative, including many of those described in Alternative 3. Figure 2.10-1 and Exhibits 1 and 2 show the existing and proposed facilities for both mines under this alternative.

Many of the plans and facility designs for Alternative 6 are similar to or the same as those described in Alternative 4, and are hereby incorporated into this alternative. Therefore, the description of expansion and reclamation facilities is tiered to the discussions presented in Section 2.8. The focus of discussion for this alternative is on those areas which would be modified from the Company Proposed Action (CPA). The proposed mine expansions and facilities modifications are presented in Section 2.10.1, followed by the proposed reclamation activities for each mine as described in Section 2.10.2. Modifications to ZMI's proposed monitoring programs and research studies are described in Section 2.10.3. Section 2.10.4 contains an assessment of other activities which are reasonably foreseeable should Alternative 6 be implemented.

2.10.1 Mitigated Mine Expansions

The location and currently permitted areas of the Zortman Mine, and the mine expansion with relocation of the waste rock repository to Ruby Flats, are shown on Figure 2.10-1 and Exhibit 1, located in the map pocket of this document. Total disturbance for the mine expansion would be approximately 1,500 acres ultimate disturbance, including buffer zones around disturbance.

ZMI has proposed several changes to current operations at the Landusky Mine, including provisions for mining an additional 7.6 million tons of ore and 7 million tons of waste rock. Service facilities to support these operations would include a limestone quarry and expanded shale pit excavations. The location of the currently permitted mine area and proposed facilities under this alternative is shown on Figure 2.10-1 and Exhibit 2, located in the map pocket of this document. This alternative would also allow ZMI to continue to use open-pit mining and heap-leach mineral processing to extract gold and silver from ore, with few modifications from the CPA. The quantity of ore to be mined under this application would constitute slightly less than one year of additional mining at the facility. No additional workers are anticipated to be hired under this expansion proposal.

Under this alternative, ZMI would continue to use open-pit mining and heap-leach mineral processing to extract gold and silver from ore at both mines as described in Alternative 4, Section 2.8.1. Because many aspects of this alternative are similar to the CPA, mine operations are summarized with reference to more complete descriptions in Alternative 4. Additional detail is provided where a modification from the CPA would occur. Most of the discussion is centered on expanded operations at the Zortman Mine, since there would be little modified from the Landusky Mine operations described in Section 2.8.1. The major operational modifications from the CPA include:

- The 60-million tons of waste rock generated at the Zortman Mine would be placed in a repository constructed on the Ruby Flats, just east of the Goslin Flats heap leach pad. The waste rock repository would be lined on the bottom with a solution detection and collection system to reduce the potential for contamination of area water resources.

- Rerouting of the County-owned Seven Mile Road, that connects the town of Zortman with U.S. Highway 191, around the new waste rock repository.

Zortman Mine Expansion: Ore production would be approximately 60,000 to 80,000 tons per day, with mining and leaching operations performed on a year-round basis. Mining and related operations would take place 7 days a week, 24 hours per day, 350 days per year. ZMI projects that the CPA work force would be similar to current operations, with approximately 260-280 full-time employees, depending on seasonal requirements. Modifications to the mine expansion should not measurably change the rate of operations or the work force.

Landusky Mine Expansion: The significant modification to the CPA under this alternative concerns water control. Post-reclamation pit runoff would be routed into Montana Gulch as surface flow instead of through the August Drain tunnel.

2.10.1.1 Mine Pit Expansion

Mine pit expansion at the Zortman Mine would not change from that described in Alternative 4, Section 2.8.1.1. The outer edges of the pit would be extended outward 600 or more feet from the current pit configuration. The pit would be deepened approximately 500 feet in some ore zones, to a lowest point of about 4,500 feet. A plan view of the pit complex was shown on Figure 2.8-3, with pit cross-sections displayed in Figures 2.8-4 and 2.8-5.

The proposed mine pit expansion for the Landusky Mine would involve lateral and vertical expansion of the existing Queen Rose/Suprise and August/Little Ben pits, and the South Gold Bug, which is an extension of the existing Gold Bug pit. A plan view of the ultimate pit complex was shown on Figure 2.8-6, with typical cross sections of the pit expansions in Figures 2.8-7 and 2.8-8.

Mining Methods

Conventional open-pit mine methods (drill, blast, and transport) would be used. The mining description provided in Alternative 4, Section 2.8.1.1 is applicable to this alternative unless otherwise noted in specific sections.

Rock Characterization

The materials and their relative amounts to be mined during expanded operations at the two mines were described in Alternative 4, Section 2.8.1.1. The geochemical sampling and waste rock characterization program proposed by ZMI, and described in Section 2.8.1.1, would be implemented under this alternative. (Mitigations have been added restricting the use of certain waste rock types in reclamation.)

Waste Rock Handling

Waste rock generated at the Zortman Mine would be hauled by truck to stockpiles near the head of the conveyor system and the 84 leach pad (see Figure 2.10-1). The waste rock would be crushed to accommodate transport on the conveyor system. Another primary crusher would probably be needed at the head of the conveyor system so that waste rock is not crushed in the primary ore crusher. Waste rock would be loaded onto the conveyor and shipped to a waste rock stockpile near the Goslin Flats leach pad to await further transport, or loaded directly into haul trucks for a mile-long haul to the Ruby Flats repository. Due to scheduling difficulties with multiple transfer points, waste rock segregation within the waste rock repository, on the basis of total sulfur content as is required for other alternatives, would not be relied upon to control ARD generation. Instead, the waste rock repository would be lined in a manner similar to the Goslin Flats heap leach pad, with a solution containment and collection system.

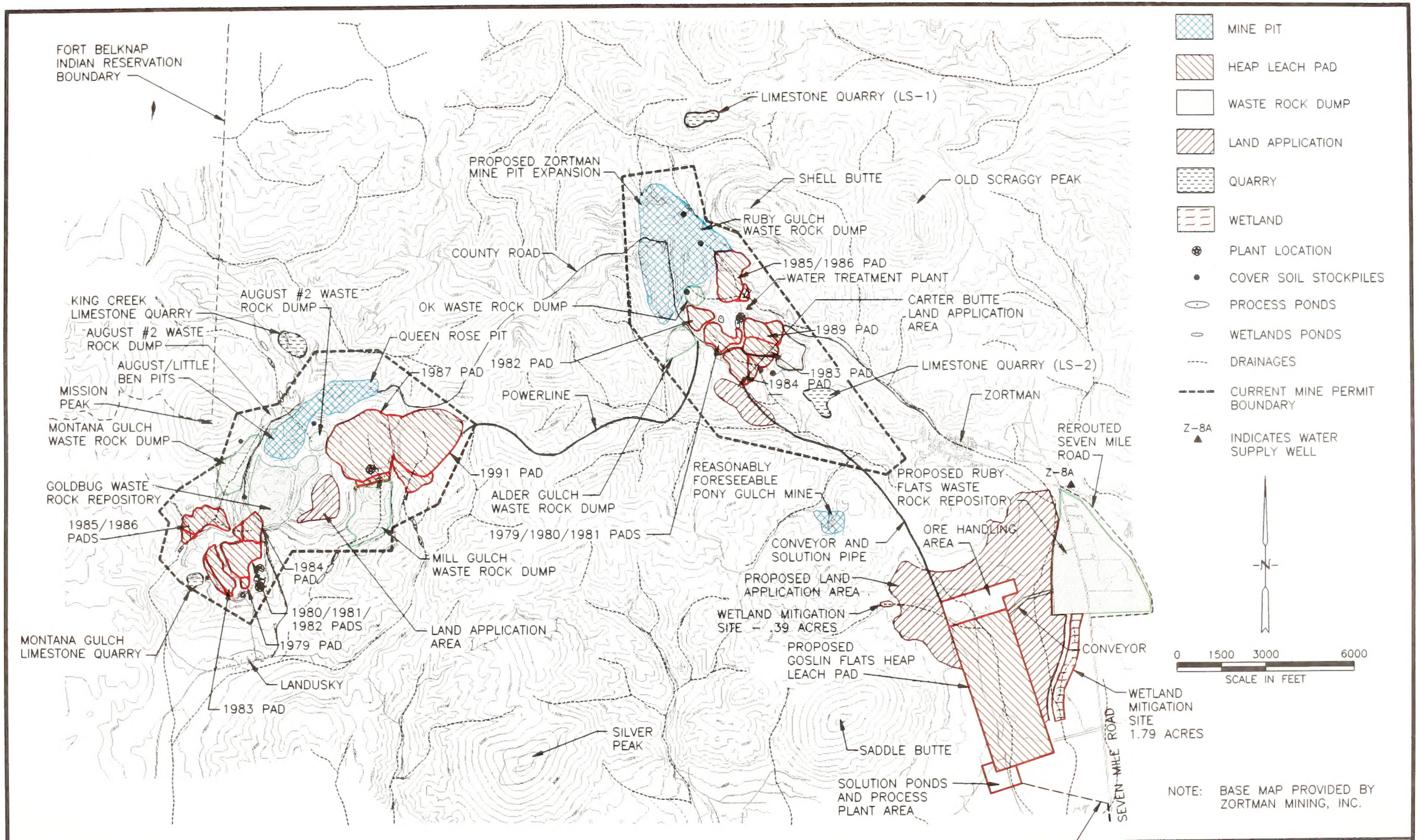
Alternative 1, Section 2.5.1.1 also describes how waste rock would be handled and designated for use in reclamation and construction at the Landusky Mine based on geochemical characteristics. No changes from that strategy are required in this alternative, except that material used in construction purposes and as a capillary break must meet the geochemical and lithologic criteria described in Section 2.10.2.

2.10.1.2 Crushing Operation

The basic process employed under this alternative for ore crushing at the Zortman Mine would not change from that described in Alternative 4, Section 2.8.1.2. However, an additional primary crusher for waste rock size reduction would be necessary near the head of the conveyor system. Mining of the deeper portions of the Queen Rose/Suprise, August/Little Ben, or South Gold Bug pits at the Landusky Mine would not require crushing or special handling for leaching purposes.

2.10.1.3 Conveyor System

The sizing of the overland conveyor system would not change for this alternative, even though the conveyor would also be used for waste rock transport. Other



ALTERNATIVE 6: MAJOR NEW FACILITIES INCLUDE GOLSIN FLATS HEAP LEACH PAD, THE RUBY FLATS WASTE ROCK REPOSITORY, AND THE ZORTMAN MINE PIT EXPANSION

ALTERNATIVE 6
ZORTMAN-LANDUSKY
EXISTING AND PROPOSED
FACILITY LOCATIONS

FIG. 2.10-1

ZLF-ALT6

details concerning the conveyor design, construction, and operation are provided in Alternative 4, Section 2.8.1.3.

2.10.1.4 New Heap Leach Pads

The new ore heap leaching facility proposed for Goslin Flats would not change from that described in Alternative 4. Section 2.8.1.4 describes the leach pad construction and operation, solution management operation of the processing plant, and handling of reagents. Figures 2.8-10 and 2.8-11 illustrate the heap leach pad design from plan and cross-sectional views, respectively.

There would be no change from the CPA at the Landusky Mine. The 7.6 million tons of ore from the expanded mining operations would be taken to the 87/91 leach pad for processing. This leach pad has already been constructed but could accommodate this additional ore without additional disturbance or liner construction.

2.10.1.5 Waste Rock Repositories

Ruby Flats

The waste rock repository for the Zortman Mine would be constructed on the Ruby Flats, just northeast of the Goslin Flats heap leach pad (see Figure 2.10-1). The waste rock repository would be designed to hold 60 million tons. The repository would encompass approximately 203 acres, of which about 140 acres are privately owned at this time by the Square Butte Grazing Association. The facility would be three sided, and stand approximately 300 feet high when fully constructed.

Seven-Mile Road would have to be rerouted around the waste rock facility to the east to accommodate this site and design. In addition, the town of Zortman's community water supply well (Z-8a, as shown on Figure 2.10-1 and Exhibit 1) is located near the northwest corner of the Ruby Flats repository. For this reason, the repository would be constructed over a liner with solution collection system as additional assurance that the water supply well does not become contaminated from the waste rock repository.

The footprint of the waste rock repository would be cleared of debris, stripped of cover soil, and graded to direct water or seepage to capture ponds at the toe (southwest corner) of the facility. The repository would be constructed from the bottom up, with haul roads developed on repository perimeters as the facility grows. Slopes of the repository would be no greater than 3H:1V. Temporary diversion channels, designed to handle peak flow from a 6.33-inch event with at least one foot of remaining freeboard, would be constructed as necessary to prevent run-on water from coming in contact with waste rock.

Waste rock would not be segregated within the waste rock repository on the basis of total sulfur content, as is required for other alternatives. This waste rock repository would be lined in a manner similar to the Goslin Flats heap leach pad, with a solution containment and collection system at the base. Seepage collected from the repository would be either treated and discharged, or used in the leach pad process circuit.

Gold Bug

As described in the Alternative 4 (Section 2.8.1.5), about 7 million additional tons of waste rock would be mined and disposed of in the Gold Bug Waste Repository or backfilled in the Queen Rose pit at the Landusky Mine. The nominal slope of the repository would be built at 3H:1V, and drainage benches (25 feet wide) would be placed every 100 vertical feet. Reclamation at the Gold Bug would continue to occur concurrent with mining activities. Section 2.10.2.5 provides more information on the repository reclamation program.

2.10.1.6 Other Features and Facilities

Office/Laboratory Facilities

This alternative would not change the locations or functions of ZMI's office and laboratory facilities. The main office building for ZMI is located in the town of Zortman. The production assay lab is located across the street from the main office in a separate building. The laboratory and office functions would continue as described in Alternative 1, Section 2.5.1.5.

Access and Haul Roads

The road network described in Alternative 4, Section 2.8.1.6 would be developed under this alternative as well. An additional haul road would need to be developed to transport waste rock from the conveyor off-load area stockpiles to the repository on the Ruby Flats. As shown on Figure 2.10-1, Seven-Mile Road would be re-routed just south of the Ruby Flats waste rock repository. The new route would extend along the southern and eastern borders of the waste rock repository. At the Landusky Mine, a haul road would be constructed in the disturbance area for accessing the South Gold Bug Pit. Other access or haul roads would remain or be constructed on existing disturbed areas

within the pits. The 2,500 feet of haul road to the King Creek limestone quarry would be widened from 20 to 60 feet, resulting in an additional total disturbance of 5.7 acres.

Power and Water Supply

For the Zortman Mine, power requirements for the mine expansion and ore processing facilities differ somewhat from that described for the CPA. Transportation of up to 60-million additional tons of waste rock on the conveyor system would generate more power than that produced by the CPA. This surplus power from the conveyor would be redirected back to the power grid.

Water supplies are likely to be similar as described for the CPA in Section 2.8.1.6. Additional water could be required for road dust control since there would be a larger network of haul roads near the mine, and increased truck traffic to transport ore and bring in clay from the Seaford pit.

No changes are proposed in the current power and water supply systems for the Landusky Mine. Electrical power is obtained from the Landusky grid, which is supplied by the Big Flat Power Cooperative through an existing 23 kV line. Potable water is obtained from groundwater wells. Process water is obtained from precipitation and groundwater appropriation.

Sewage Treatment

Septic treatment systems would be the same as those described for Alternative 4, Section 2.5.1.5.

Chemical Use

Chemicals uses and inventory would be the same as those described for Alternative 4 for the Zortman Mine (Section 2.8.1.8). There would be little change from the existing chemical uses and inventory described for presently permitted operations in Alternative 1.

No changes are proposed from the current inventory and use of potentially hazardous materials at the Landusky Mine. See Alternative 1, Section 2.5.1.7 for additional information.

Waste Disposal

The types, amounts, and methods of disposal for solid waste generated under this alternative would be the same as those described for Alternative 4, Section 2.8.1.8 and further discussed in Section 3.14.

2.10.1.7 Water Management

This section presents an overview of water management plans prepared by ZMI, with additional mitigating measures developed by the agencies, to mitigate impacts from existing and proposed expanded mining operations. It includes a description of measures that have been or would be implemented for management of process water, storm water and mine drainage. This section is divided into discussions on surface water runoff control, water capture, water treatment and LAD. Many of the water management measures proposed by ZMI in Alternative 4, Section 2.8.1.7 would apply to this alternative and are not repeated. Additional detail on measures to improve and maintain water quality are contained in the Water Quality Improvement Plan which is presented in Appendix A.

Objective: The objective under this and all other alternatives is to protect beneficial use and to achieve and maintain compliance with water quality standards.

Approach: This alternative relies on a combination of source control and active treatment to protect water quality. Low permeability reclamation covers are used to limit infiltration of precipitation into mine waste, thereby restricting water contact with potentially acid generating materials. Diversion of runon water is used to prevent stored acidity within the mine waste from being transported into adjacent surface or ground waters. Capture and treatment of impacted waters is required initially and used as a secondary measure in the long-term. Selective handling of waste rock is not part of this alternative for waste placed on the Ruby Flats Waste Rock Repository. Low permeability barriers are used above and below the waste as the primary mechanism to isolate reactive mine waste.

The emphasis is to institute source controls to prevent contact of surface or ground waters with potentially acid generating materials. Reclamation covers which would greatly reduce or perhaps eliminate the need for long-term water collection and treatment are required. The management of mine water requires keeping mine drainage, storm water and process waters segregated so that each can be handled using the technology most appropriate to each waters character.

Additional design measures have been incorporated in this alternative to facilitate water management. The design criteria for stormwater diversions would be increased to convey runoff from the 6.33-inch, 24-hour storm event with 1-foot of freeboard.

The proposed waste rock repository would be relocated from Carter Gulch to Ruby Flats. This relatively flat, open area, would provide improved management of stormwater and mine drainage associated with the waste rock repository.

Surface Water Runoff Control

With the exception of the Ruby Flats Waste Rock Repository, most surface water runoff control features described in Alternative 4, Section 2.8.1.7 would apply to this alternative. All drainage and diversion ditches would have to be able to pass the peak flow from the 6.33-inch, 24-hour design storm event with 1 foot of freeboard as a safety measure.

Diversion channels would be trapezoidal or V shaped, lined with geotextile to prevent piping and rip-rapped with durable, non-acid forming rock sized for drainage area requirements. All diversion ditches would have road access for maintenance purposes. Maintenance would consist of removal of sediment load and repositioning of rip-rap as required. Sediment would be disposed of in the waste rock repository.

Mine Pits - At the Zortman Mine, the above pit diversions, 5000-foot elevation diversion and pit floor drainage plans would all be constructed as described in Alternative 4 for management of surface water and prevention of groundwater recharge. The only significant difference would be the additional backfilling of the pits with the 85/86 leach pad spent ore, and excess Ruby Gulch tailings. This would facilitate runoff of surface waters from the mine pits into Ruby Gulch.

At the Landusky Mine, diversions would be constructed to route storm water away from pit disturbance limits. The pit bottoms would be backfilled to the 4,740-foot elevation at the south end with material removed from area drainages that are impacting water quality. Enhanced reclamation covers would be placed over the backfilled pit floor area to limit infiltration of precipitation through this material, thereby reducing recharge to the August drain tunnel which discharges beneath the Montana Gulch waste rock dump. The pit floor would be sloped to not impound runoff in the pit. A drainage cutout notch would be constructed across the bedrock divide between the August Pit and Montana Gulch. The channel would be sized to handle runoff from a 6.33-inch, 24-hour storm event. Runoff from the pit area would be routed through this channel and along the existing haul road route around the Montana Gulch Waste Rock Dump and 85/86 leach pad. The water would flow into settling/treatment ponds prior to discharging to Montana Gulch below the 85/86 leach pad.

Runoff from the pit highwall may be of poor quality and constitute mine drainage. Portions of the pit walls that are potentially acid forming and cannot be capped would have diversions installed above the highwalls where access allows. These diversions would route storm water away from the pit highwalls. This flow would be captured in trenches at the highwall base and kept separate from storm water which falls on the pit floor. At the Landusky Mine, this flow would also be routed to Montana Gulch and treated, if necessary, prior to release. The diversions would be designed to be maintenance free to the extent possible and pass the peak flow from a 6.33-inch, 24-hour storm event with one foot of freeboard. Highwalls and diversion structures would be visually inspected on a periodic basis and repairs made as necessary.

Leach Pads - Diversion ditches constructed around the leach pads to prevent the inflow of storm water would be upgraded to pass runoff from the 6.33-inch, 24-hour storm event.

The 85/86 leach pad at the Zortman Mine would be detoxified, removed from upper Ruby Gulch, and used to backfill the mine pits or re-leached. Discharges exposed in this drainage would be directed to lined channels and routed to the Ruby Gulch capture ponds for any necessary treatment.

At the Landusky Mine, a drainage trench would be excavated from the side of the west tributary of Montana Gulch that is blocked by the 85/86 leach pad. This would involve excavating approximately 36,000 tons of material with a disturbance of approximately one-quarter acre.

Waste Rock Repositories - At the Zortman Mine, the existing Alder Gulch waste rock dump would be removed and the dump footprint reclaimed. This would remove a current source of contamination from Carter Gulch.

The Ruby Flats waste rock repository would be constructed over a liner system similar to that proposed for the Goslin Flats leach pad. This would be necessary to limit discharge to groundwater given the close proximity of the Zortman community water well. This liner system would collect any leachate that develops within the waste repository and convey it to a collection point for necessary treatment and discharge. Upgradient diversion channels would be constructed to prevent runon water from coming in contact with the waste rock.

No changes would be made to the present drainage control features for the Gold Bug and Mill Gulch waste repositories at the Landusky Mine. Portions of the Montana Gulch waste rock dump may be used for reclamation material or pit backfill. The remaining dump would have runoff controls installed adequate for the flow from the design storm event.

Water Capture

Capture systems consisting of ponds, diversions, slurry cut-off walls, and recovery wells would be used to capture mine drainage to prevent deterioration of water quality in adjacent drainages. Storm water would be segregated from mine drainage. Impacted water would not be released to surface water prior to treatment. Data would be collected in accordance with the monitoring plan to regularly monitor water quality and capture system effectiveness.

No changes would be made to most seepage water capture and treatment systems from those described in the CPA. The Alder Spur capture system would be resized for seepage from the design event. A new water capture system would be installed downgradient of the Ruby Flats waste rock repository to collect leakage or runoff from the repository (see Appendix A). All captured seepage water would be pumped to the Zortman water treatment plant for treatment and release into Ruby Gulch.

The existing seepage capture systems at the Landusky Mine would be sized to handle seepage generated by the 6.33-inch, 24-hour storm event. All captured seepage water would be pumped to the new Landusky water treatment plan for treatment and release into Montana Gulch.

As described for Alternative 5, Section 2.9.1.7 all process would be enclosed with 8-foot fencing capable of excluding big game and other large animals. Seepage capture ponds and sumps would be inspected on a weekly basis for routine maintenance or repairs, if necessary.

Additional information concerning the capture systems is found in the Water Quality Improvement Plan, Appendix A.

Water Treatment

The location and function of the water treatment plants would remain as described in Alternative 1 and Appendix A. ZMI constructed a 2,000-gpm water treatment plant in May 1994 to treat seepage water captured at the toe of existing mine waste rock dumps at the Zortman Mine. The plant operates at a rate of 200 to 2,000 gpm depending on factors such as precipitation amounts and seasonal operating conditions. Another water treatment plant is planned for the Landusky Mine and would be located in the Montana Gulch area. Interim effluent discharge standards from the plant are BAT for mine waters (40 CFR §440.100). Establishment of final effluent limits and outfall points would occur as part of MPDES permit development.

The water treatment plants would continue to operate until final reclamation measures have successfully produced effluent that meets the water quality standards. Under this alternative, the placement of enhanced reclamation covers, long-term capture and treatment may not be necessary to meet water quality objectives in many of the affected drainages. However, it is provided for as a contingency. As water quality meets discharge standards and the appropriate agencies approve of release of the waters, capture ponds, sumps and pumpbacks systems would be dismantled and the sites reclaimed.

Land Application Disposal

As described for the CPA, provisions for land application disposal are required by the regulatory agencies for final heap draindown at mine closure, or in the case of an extreme precipitation event that overwhelms the capacity of the leaching circuit. Most of the discussion in Alternative 4, Section 2.8.1.7 applies to this Alternative.

At the Zortman Mine, a total of 390 acres has been identified as suitable for use as a land application area while 285 acres near the Goslin Flats heap leach pad have been proposed for use as land application disposal sites during closure activities (see Figure 2.8-15). The location of the Ruby Flats waste rock repository would reduce the area available for land application by approximately 40 acres.

As with Alternative 4, no operational land application disposal is planned as part of this alternative, and no emergency land application should be required during operations. In the event land application is required, it would be conducted as described in Alternative 1, Section 2.5.1.6 for currently permitted operations.

2.10.2 Mitigated Mine Reclamation

The agencies have developed modifications to ZMI's proposed reclamation procedures which would: (1) reduce infiltration into areas with the potential to cause acidic drainage, (2) remove waste rock dumps and other sources currently causing degradation of surface water or groundwater, and (3) implement the Water Quality Improvement Plan to further mitigate effects of ARD should reclamation procedures fail to adequately protect water resources. Many of these reclamation modifications were described in detail in Section 2.7.2, for the Mitigated Reclamation for Alternative 3. However, that alternative describes reclamation actions to be taken if ZMI's proposal for mine expansion is not approved. This alternative describes modified reclamation actions that would take place in conjunction with the mine expansion. The major reclamation modifications to be incorporated in this alternative include:

- Unless specifically identified below, mine waste rock facilities and ore heaps are assumed to be acid generating and would be reclaimed using improved reclamation covers. Cover soil on the facilities would be removed, stockpiled, and reused.

- With the exception of most leach pad dikes, existing facilities would be reclaimed to an overall 3H:1V slope with constructed benches every 100 vertical feet between benches. This measure would reduce erosion and soil loss, increase overall surface reclamation success, and result in more stable facilities. In order to achieve the slope reduction while minimizing additional land disturbance in adjacent drainages, some material may have to be off-loaded from existing facilities and backfilled into the pits.

- To enhance the probability of long-term reclamation success, soil loss from reclaimed areas must be less than 2 tons/acre/year.

- Reclamation Cover C would be modified to include 6 inches of compacted clay (as opposed to 3 inches of compacted clay) between the bottom substrate and the PVC liner. The PVC liner thickness would be increased to 30 mil. For the purpose of discussion in this and future alternatives, this cover will be known as "Modified Reclamation Cover C."

- In order to classify as "NAG" and be used without restriction in construction and reclamation, thereby ensuring the potentially acid generating materials are not placed in areas potentially exposed to surface water and the open atmosphere, waste rock:

  1. Cannot be composed of breccia, felsic gneiss, monzonite, quartzite, or trachyte lithologies;

  2. If amphibolite, mafic gneiss, shale, dolomite or limestone must have a total sulfur content less than or equal to 0.8 percent, and a paste pH of 6.0 or greater;

  3. If syenite, must have a total sulfur content less than or equal to 0.2 percent, a paste pH of 6.5 or greater, and a NNP greater than or equal to 0;

  4. Must meet the criteria above as demonstrated by sampling and analyzing lithologies from every blasthole providing non-acid generating material for total sulfur, Paste pH and NP. All blastholes within a discrete mineable block (25 feet x 25 feet) must meet these criteria.

  5. If syenite, can only be used in reclamation covers and not for fill or other construction.

- To ensure that only NAG materials are used in facilities transporting surface water or seepage water, material used for capillary break/drainage layers may be obtained from the unmineralized sources specified in Section 2.10.2.1.

- Rock underdrains would be built with durable, unmineralized limestone as an additional precaution to buffer acidic drainage.

- No trees would be used in revegetation except on a limited basis for visual impact mitigation. Only grasses, forbs and shrubs would be used to enhance wildlife habitat. Crested wheatgrass would not be used in the reclamation seed mix.

- Vegetative cover must achieve 90 percent of that demonstrated in adjacent, natural communities of similar composition and location to be considered acceptable.

- An expanded monitoring program would be implemented, as described in Section 2.10.3, and reclamation viability would be monitored by ZMI until the agencies have approved final closure and released the mine reclamation bond.

- Reclaimed facilities including the Goslin Flats leach pad would be recontoured to provide a topography

that blends into the surrounding landscape. Straight edges would be rounded. Large, flat surface areas would be broken with changes in contour resembling natural drainage patterns.

Zortman Mine

- The back-filled pits would be graded so that runoff drains freely, without impoundment in the pit, into the Ruby Gulch drainage.
- The 89 leach pad dike would be tested for sulfur content as described in Section 2.8.2.2, and re-reclaimed if sulfur exceeds 0.5 percent in more than 10 percent of the material tested.
- After detoxification, the Zortman 85/86 leach pad and dike would be removed to create a free draining surface and placed in the pit as backfill material prior to pit floor reclamation.
- The OK waste rock dump and Upper Alder Gulch would be removed and used to backfill the pit complex or leached on the pad. Cover soil would be re-salvaged and the waste rock footprint reclaimed.
- The sulfide storage area in Ruby Gulch would also be removed and placed on the Goslin Flats leach pad for ore processing.
- The tailing in Ruby Gulch above the town of Zortman would be removed from the drainage and placed in the pit complex or used as reclamation or construction material. The drainage would be restored as mitigation for existing disturbance to waters of the United States by other Zortman and Landusky mines facilities.

Landusky Mine

- The Landusky 91 leach pad dike would be re-reclaimed as appropriate to allow redistribution of spent ore to the south, west and east of the 87/91 pad. This action would eliminate the potential for surface water from the 87/91 pad to runoff north of the mine site into drainages on the Fort Belknap Reservation.
- Existing reclamation covers on the Gold Bug waste rock repository and the Mill Gulch waste rock dump may require supplemental cover soil to further reduce surface water infiltration.
- To unblock surface water drainage in the western tributary of Montana Gulch a drainage channel would be constructed along the west margin of the 85/86 leach pad.
- Highwall runoff would be diverted from the mine pits into Montana Gulch and treated if necessary.
- Backfill the Landusky Mine pits to a minimum elevation of 4,740 feet (at the south end of the pit complex/drainage ditch) to create a surface which will freely drain into Montana Gulch, thereby reducing the potential for precipitation and surface water runon to infiltrate through acidic materials and into the groundwater. Approximately 3.6 million tons of backfill would be required to reach this level. Material used in backfill would come from existing waste rock dumps and leach pads, mined waste rock, or construction of the drainage channel.
- Runoff from the Queen Rose/Suprise and August/Little Ben pit areas would be directed through a drainage notch between the August/Little Ben pit and Montana Gulch. Surface water would be routed to Montana Gulch immediately below the waste rock dump.

Final reclamation of all Zortman Mine facilities is anticipated to occur within 3 years after the Goslin Flats leach pad has been detoxified and liner perforated. Final reclamation of all Landusky Mine facilities is anticipated to occur within 3 years after the 87/91 leach pad has been detoxified and liner perforated.

The following sections summarize the specific reclamation plans and actions for each of the major disturbance areas, and provide a description of prescribed modifications to the reclamation procedures.

2.10.2.1 Reclamation Materials

Reclamation materials would be required for construction and installation of reclamation caps and for use in construction of drains and diversions. The primary materials to be used in reclamation covers would include non-acid forming waste rock and limestone, clays and cover soil. These materials and their sources were described in Alternative 4, Section 2.8.2.1. The following sections summarize the uses for the reclamation materials and modifications from the CPA.

Non-Acid Forming Material

Non-acid forming materials would be used in reclamation covers on all disturbance areas. The reclamation covers used in this alternative require a capillary break/drainage layer of 36 inches, to be composed of a suitable non-acid generating waste rock or limestone.

Under this alternative, the waste rock must meet the geochemical and lithologic criteria described in the beginning of Section 2.10.2 to be suitable for construction purposes and reclamation cover. It is likely that sufficient waste rock of suitable quality would be available at the Zortman Mine from new mining for use in reclamation covers and construction, so that limestone would not be required as a capillary break material.

Limestone/Dolomite

Limestone would be used in construction and reclamation of the Goslin Flats leach pad at the Zortman Mine. Limestone needed for construction purposes or in reclamation covers would be mined from LS-1 (see Figure 2.5-2). Mining and haul road development to this source would occur as described in Alternative 3, Section 2.7.2.1.

Dolomite and limestone from outcrops within the Landusky Mine permit area have recently been used to provide a 3-foot buffering liner across the floor of the 4,640 bench in the Gold Bug waste rock repository at the Landusky Mine. Limestone and dolomite from the mine pits could also be used as capillary break material in the reclamation covers. Alternative 3, Section 2.7.2.1 and Alternative 4, Section 2.8.2.1 provide a description of the activities to be conducted to quarry limestone from the King Creek quarry location.

Clay

As described in Alternative 4, Section 2.8.2.1 clay would be used for leach pad liner construction at the Zortman Mine as well as cover material on waste rock repositories, heap leach pads, haul roads, and pit benches and floors to restrict moisture infiltration. Clay required for construction and reclamation of facilities would be mined from the Seaford clay pit. ZMI mine trucks or a mine contractor would use Seven Mile Road to haul clay from the Seaford pit to the Zortman Mine facilities (see Figure 2.5-2).

At the Landusky Mine, clay is used as a component layer of the caps which have been placed on the Mill Gulch waste rock dump and 91 leach pad dike. Two 6-inch lifts of clay would be used in disturbed areas where Reclamation Cover B is installed, and one 6-inch lift of clay would be used in areas capped by Modified Reclamation Cover C. A 6-inch layer of clay is also used in Reclamation Cover A, to be placed on some haul road disturbances and pit benches. Clay used in Landusky Mine reclamation comes from the Williams Clay pit located approximately 2 miles west of the town of Landusky. Approximately 1.3 million yards of clay would be used in the reclamation covers.

Cover Soil

Cover soil at the Zortman Mine is currently obtained from one of three stockpiles listed, with soil volumes, on Table 2.5-9. These stockpiles would probably have insufficient supplies to adequately cover all disturbances to the extent required under this alternative. Approximately 550,000 yd^3 yards of cover soil would be required. Additional cover soil would be generated during construction of the Goslin Flats heap leach pad and Ruby Flats waste rock repository. Construction of these two facilities would produce cover soil quantities for all Zortman Mine reclamation requirements. Another source of cover soil is the material salvaged during re-reclamation activities on facilities which have already been cover soiled and revegetated. It is possible that cover soil for Zortman Mine reclamation would have to be supplemented with cover soil from the Landusky Mine stockpiles.

Cover soil at the Landusky Mine would be obtained from one of the four cover soil storage areas listed on Table 2.5-10. Stockpile volumes are also shown on this table.

2.10.2.2 Reclamation Covers

Under this alternative all disturbed areas not being used as pit backfill (with the exceptions noted such as haul roads and building-type facilities, and the 89 leach pad dike) are assumed to be acid generating and would be capped using either Reclamation Cover B or Modified Reclamation Cover C, depending on the slope of the disturbance. Reclamation Cover C would be modified from the CPA by increasing the clay layer to a compacted minimum of 6 inches thick. The PVC liner thickness would be increased to 30 mil and a geofabric would be placed between the cover soil and the capillary break. These reclamation covers are similar to the covers used during reclamation of the Mill Gulch waste rock dump.

The criteria for material to be suitable for use in the capillary break were described at the beginning of Section 2.10.2. Certain rock types would be excluded from use and those not excluded must demonstrate a sufficiently high Paste pH, sufficiently low sulfur content,

and appropriate neutralization potential. All waste rock considered for use as NAG material must come from blastholes which have been characterized according to these criteria.

The interim covers already constructed on the Mill Gulch and Gold Bug waste rock facilities would remain as permanent reclamation caps, provided that the infiltration performance criteria are met. Additional soil could be added to these covers to achieve water infiltration criteria that the agencies stipulate.

2.10.2.3 Mine Pit Reclamation

Overall slope of the final pit walls would be required to be approximately 45 degrees (1H:1V) with 30-foot flat benches every 60 vertical feet. Pit floors are to be sloped and graded to facilitate free drainage, as described above. The final pit floor (i.e., the backfilled surface) would be covered with Reclamation Cover B to prevent surface water infiltration. This alternative also requires the placement of Reclamation Cover A on pit benches prior to revegetation (where revegetation is possible), which would include the use of trees to the extent possible to reduce visual impacts.

Zortman Mine pit reclamation would occur generally as described in Alternative 4, Section 2.8.2.3 with some modification concerning the source of pit backfill materials. Approximately 9 million tons of spent ore and tailings from the 85/86 leach pad and dike, and Ruby Gulch drainage, would be placed in the pit complex as backfill in addition to the approximately 6 million tons of scheduled backfill proposed by ZMI. This material would be used to raise the pit floor to an elevation necessary to freely drain the pit and prevent surface water from ponding and infiltrating through the pit floor. This elevation is estimated to be 4,900 feet msl. Additional backfill material could come from the waste rock generated during expanded mine operations. The final pit construction would be as described in the CPA. The final pit floor would be capped with Reclamation Cover B. The final cover would be revegetated with native grasses and forbs. Pit walls not covered by backfill would be cover soiled and revegetated where possible, to include tree planting to reduce visual impacts of highwalls.

The Landusky Mine pit reclamation procedures have been developed, as follows. The pits are to be backfilled to a minimum elevation of 4,740 feet, measured at the south end of the August pit, to create a surface which would freely drain into Montana Gulch. This action would also reduce the potential for surface water infiltrating the pit floors to contact sulfide-bearing zones and create acidic drainage.

A drainage channel would be constructed across the bedrock divide between the August/Little Ben Pit and Montana Gulch, thereby preventing surface water from infiltrating to the August tunnel and redirecting flow to capture ponds by the Montana Gulch waste rock dump (see Section 2.10.1.7). Rock removed during construction of the drainage notch would be backfilled into the August/Little Ben pit. Backfill would proceed to the 4,740-foot level with concurrent backfill in the August/Little Ben pit of about 300 feet thick. Any ore-grade material encountered during excavation of the notch could be transported to the 87/91 leach pad for processing. Approximately 5 million tons of spent ore from the 85/86 leach pad and up to 8 million tons of waste rock from the Montana Gulch dump could also be used as backfill in the pit.

2.10.2.4 Leach Pad Reclamation

Tasks associated with the reclamation of the heap leach facilities include heap detoxification, surface reclamation including slope reduction, reclamation cover placement, cover soiling and revegetation, and liner perforation. These steps have been described in detail previously. Heap leach pad reclamation would generally follow the procedures outlined in Alternative 4, Section 2.8.2.4 with incorporation of the relevant modifications described in Alternative 5, Section 2.9.2.4.

Existing Heap Leach Pads

The Zortman 85/86 heap leach pad and dike would be removed and placed as backfill into the Zortman pit complex. The footprints from this facility would be tested on 100 foot centers. Those areas with total sulfur content greater than 0.5 percent sulfur would be capped with Reclamation Cover A and revegetated. Areas with lower sulfur contents would be scarified, covered with 8 inches of soil and revegetated.

Heap Detoxification

Heap detoxification for this alternative would be similar to that described in Alternative 1, Section 2.5.2.4. In summary, the spent ore on the leach pad would be rinsed repeatedly with cyanide-free water to enhance degradation of cyanide compounds left in the heap. Heap detoxification is discontinued when the solutions returning from the heap maintain less than 0.22 mg/l cyanide (measured as WAD cyanide) for a six-month period which includes a spring, high-flow surface runoff event. Heap solutions remaining after detoxification

would be pumped to a containment pond for neutralization and later land application disposal.

Surface Reclamation

The reclamation criterion for pad slopes under this alternative is a 3H:1V slope, if topography allows, but no greater than 2.5H:1V. Constructed benches must be placed every 200 feet of slope length. Slope reduction would be performed by track mounted bulldozers pushing ore heap material from the facility crest or top down over the lift slopes, using cut and fill material from each of the heap benches to obtain the desired slope. Leach pad crests, top and slopes would be capped with Reclamation Cover B (on slopes greater than 5 percent) or Modified C (on slopes 5 percent or less).

Heap retaining dikes would be reduced to a nominal slope of 2.5H:1V, or sufficient to allow placement and retention of Reclamation Cover B. The dike faces would be capped with Reclamation Cover B and revegetated to blend with existing undisturbed contact zones and reestablish vegetation communities. The reclaimed pad surfaces would be revegetated with native prairie grasses, forbs and shrubs to complete final reclamation. In order to help mitigate the visual appearance of the reclaimed heap, portions of the uppermost lift(s) of ore would be varied in thickness and location to create a variable skyline. In addition, "micro-habitat" areas would be created by scouring small depressions with earth-moving equipment during final regrading.

Liner Perforation

The heap leach pad liner system at the Zortman Mine would be perforated after pad detoxification and surface reclamation to eliminate moisture storage and any undesirable hydraulic conditions associated with the reclaimed facility. The liner would not be perforated until monitoring of the heap effluent indicates that water quality compliance has been met and risk of the formation of acid drainage is established to be minimal. The liner perforation requirements described in Alternative 3, Section 2.7.2.4 including annual and monthly monitoring, would apply to this alternative. Drain holes would be drilled through the Goslin Flats leach pad's synthetic and clay liner systems to facilitate drainage.

The Landusky Mine 87/91 heap leach pad liner system would be perforated after pad detoxification and surface reclamation to eliminate moisture storage and any undesirable hydraulic conditions associated with the reclaimed facility. The liner would not be perforated until monitoring of the heap effluent indicates that water quality compliance has been met and risk of the formation of acid drainage is established to be minimal.

2.10.2.5 Waste Rock Facilities Reclamation

Ruby Flats Waste Rock Repository

The Ruby Flats waste rock repository would be reclaimed concurrent with construction activities. Two modifications from the CPA are incorporated. First, because the waste rock repository would be lined to prevent seepage into underlying lithologies, it would have to be sloped at the foundation for solution drainage and collection. The second modification in this alternative from the CPA is that the final slope of the repository would be 3H:1V, and constructed benches must be placed every 200 feet of slope length. This reduction in slope would increase the final disturbance footprint for this facility.

Existing Waste Rock Dumps

Existing waste rock dumps at the Zortman Mine would be reclaimed as described in Alternative 5, Section 2.9.2.5.

Most of the Montana Gulch waste rock dump at the Landusky Mine would be removed and used as backfill in the pit. The remaining footprint would be tested and reclaimed with Reclamation Cover A if sulfur concentrations exceed 0.5 percent. The interim cap placed on the Mill Gulch waste rock dump would remain as a permanent cover. Reclamation Cover C would continue to be used on the Gold Bug waste rock repository. Reclaimed surfaces would be revegetated in accordance with the procedures described in Alternative 4, Section 2.8.2.8 except where modified as described in Alternative 3, Section 2.7.2.8.

2.10.2.6 Support Facilities Reclamation

Unless otherwise noted in the following sections, reclamation of support facilities would be as described in Alternative 3, Section 2.7.2.6 or in Alternative 4, Section 2.8.2.6.

Solution/Process Ponds Reclamation

Reclamation of solution and process ponds would not differ from that described in the CPA, Section 2.8.2.6.

Process Plant Site Reclamation
Final reclamation would include the removal of all structures and equipment used in the mining and processing of ore through heap leach operations. Reclamation of these facilities and footprints would not differ from that described in the CPA, Section 2.8.2.6.

Soil Stockpile Reclamation
Cover soil stockpiles would be completely depleted by the time surface reclamation activities are completed. The footprints from the soil stockpiles would be tested on 100-foot centers. Those areas with total sulfur content greater than 0.5 percent sulfur would be covered with 6 inches of clay, followed by 8 inches of cover soil and revegetated. Areas with lower sulfur contents would be scarified, covered with 8 inches of soil and revegetated.

Access and Haul Roads
Reclamation requirements for access and haul roads would be as described in Alternative 4, Section 2.8.2.6.

Limestone Quarries
Up to 13 acres would be disturbed at the LS-1 limestone quarry to provide about 1 million tons of limestone for construction and reclamation at the Zortman Mine. Up to 3 acres would be disturbed at the King Creek limestone quarry to provide reclamation materials for the Landusky Mine. The ultimate facilities development topography of the limestone quarries would be as described in Alternative 4, Section 2.8.2.6.

Clay Pits
New and old disturbances at the clay pits would undergo reclamation as described in Alternative 4, Section 2.8.2.6. All areas would be revegetated as described in Section 2.8.2.8.

Land Application Areas
Following completion of all land application operations, the land application areas would be reclaimed as described in Alternative 4, Section 2.8.2.6.

2.10.2.7 Reclamation Quality Control

The reclamation quality control procedures and requirements described in Alternative 5, Section 2.9.2.7, would apply to this alternative. Construction quality control of the waste rock repository would meet the same requirements as for the heap leach pad construction.

2.10.2.8 Revegetation Procedures

Revegetation procedures for this alternative would not be expected to differ significantly from those presented in Alternative 4, Section 2.8.2.8. However, no trees would be used in revegetation unless specifically needed to mitigate visual impacts. Only grasses, forbs, and shrubs would be used to enhance wildlife habitat. Another change is that crested wheatgrass would not be used in the reclamation seed mix. Areas disturbed would be revegetated to stabilize soil and slopes, reestablish communities ecologically comparable to pre-mine conditions, and restore watershed, wildlife, recreational and aesthetic values that meet post-operation land use objectives. Vegetative cover must achieve 90 percent of that demonstrated in adjacent, natural communities of similar composition and location. Stock grazing would be restricted in revegetated areas until the vegetation canopy is 90 percent or greater of the reference area.

2.10.3 Monitoring Programs and Research Studies

The monitoring programs and research studies outlined in Alternatives 1 and 4, Sections 2.5.3 and 2.8.3, respectively would apply to this alternative. A reclamation monitoring program would be instituted to provide ongoing evaluation of surface reclamation viability.

2.10.3.1 Water Resources

The monitoring program for groundwater and surface water would continue as described in Alternatives 1 and 4. Some monitoring wells or surface water monitoring sites could be relocated as a result of actions taken to reduce slopes of heap leach facilities and waste rock dumps. All monitoring required by the Water Quality Improvement Plan would be incorporated into this alternative. ZMI would be required to establish a monitoring program for operation and maintenance of land application disposal areas. This program would be as described for Alternative 5 in Section 2.9.3.1.

The expanded network of monitoring wells and surface water monitoring locations described in Section 2.7.3.1 is incorporated into this alternative. In addition, two alluvial and two bedrock monitoring wells would be installed in Camp Creek downgradient of the waste rock repository on the Ruby Terrace. One alluvial/bedrock well pair would be installed upgradient of the waste rock repository. One surface water monitoring station would be installed downstream of the waste rock repository on

Camp Creek. The monitoring frequency and analytes for all monitoring locations would also be as described in Section 2.7.3.1.

2.10.3.2 Reclamation Surface Performance Study

Some expansion of the reclamation surface performance study would result from implementation of this alternative. ZMI would be required to monitor seepage from waste rock facilities on a frequency sufficient to develop long-term hydrographs for each site. The hydrographs would be used to assess and predict how and when seepage responds to high flow seasons or storm events. The hydrographs would also provide a tool for predicting opportunistic sampling events to evaluate changes in seepage quality.

2.10.3.3 Surface Reclamation Monitoring Programs

ZMI would implement a program to monitor long term viability of surface reclamation until such time as the agencies release the Mine Reclamation Bond. This program was described in Section 2.9.3.3.

2.10.3.4 Other Monitoring Programs

No changes are anticipated to the remainder of the monitoring programs from the descriptions provided in Alternative 4, Section 2.8.3.

2.10.4 Reasonably Foreseeable Future Actions

2.10.4.1 Powerline

An upgraded, 69-kV powerline as described in Alternative 4, Section 2.8.4.1 is a reasonably foreseeable development for this alternative.

2.10.4.2 Mine Activities

Proposals for future mine activities would be the same as described under Alternative 4, Section 2.8.4.2. The Pony Gulch ore deposit is likely to be proposed for mining in the future. Additional limestone resources are also likely to be proposed for mining. Passive water treatment measures would be proposed downgradient of mine facilities.

Since Alternative 6 is almost identical with respect to proposed mining at the Landusky Mine, foreseeable activities under this alternative are the same as previously described for Alternative 4, Section 2.8.4.2. These developments include additional ore extraction from the existing pits, generation of a significant amount of waste rock as new ore is mined, construction and operation of a new leach pad in the Queen Rose/Suprise pit or at an alternate site, and the construction and operation of new or expanded water treatment facilities would be foreseeable.

2.10.4.3 Exploration Activities

Proposals for future exploration activities would be the same as described under Alternative 4, Section 2.8.4.3. The additional 200,000 linear feet of road and trench construction, with 600 drillsites, over a 10-year period could be proposed. Exploration could locate a minable deposit adjacent to the conveyor route.

2.11 ALTERNATIVE 7 (PREFERRED ALTERNATIVE): MITIGATED EXPANSION AND RECLAMATION WITH WASTE ROCK REPOSITORY LOCATED ON EXISTING MINE FACILITIES RATHER THAN IN CARTER GULCH

Alternative 7 would allow expansion of both the Zortman and Landusky mines but impose agency-developed mitigation on the expansion and reclamation activities. The major modification to ZMI's expansion plans (see Alternative 4, Section 2.8) would be at the Zortman Mine, where the proposed waste rock repository would be constructed on top of existing facilities at the mine. Based upon a preliminary design for a waste rock cap and pit contour at the Zortman Mine site (Golder Associates, Inc. 1995), the agencies considered this alternative as a way to reduce the amount of land disturbance associated with expanded mining activities, reduce the potential for impacts to water resources in drainages other than Ruby Gulch and Alder Spur, and enhance reclamation opportunities on existing facilities. This alternative would also reduce the amount of reclamation materials by concentrating disturbed areas. The reclamation covers presented in Alternative 3, Section 2.7.2 are used in this alternative as well. A significant modification of the Landusky reclamation requirements would be for ZMI to backfill the Landusky Mine pits to a level which would allow free drainage to Montana Gulch. Other mitigating measures designed to reduce or eliminate environmental impacts are incorporated into this alternative. Figure 2.11-1 and Exhibits 1 and 2 show the existing and proposed facilities at both mines associated with this alternative.

Many of the plans and facility designs for Alternative 7 are similar to or the same as those described in Alternative 4, and are hereby incorporated into this alternative. Therefore, the description of expansion and reclamation facilities is tiered to the discussion presented in Section 2.8. The focus of discussion for this alternative is on those areas which would be modified from the Company Proposed Action (CPA). The proposed mine expansions and facilities modifications are presented, followed by the proposed reclamation activities. Modifications to ZMI's proposed monitoring programs and research studies are described in Section 2.11.3. Section 2.11.4 contains an assessment of other activities which are reasonably foreseeable should Alternative 7 be implemented.

2.11.1 Mitigated Mine Expansions

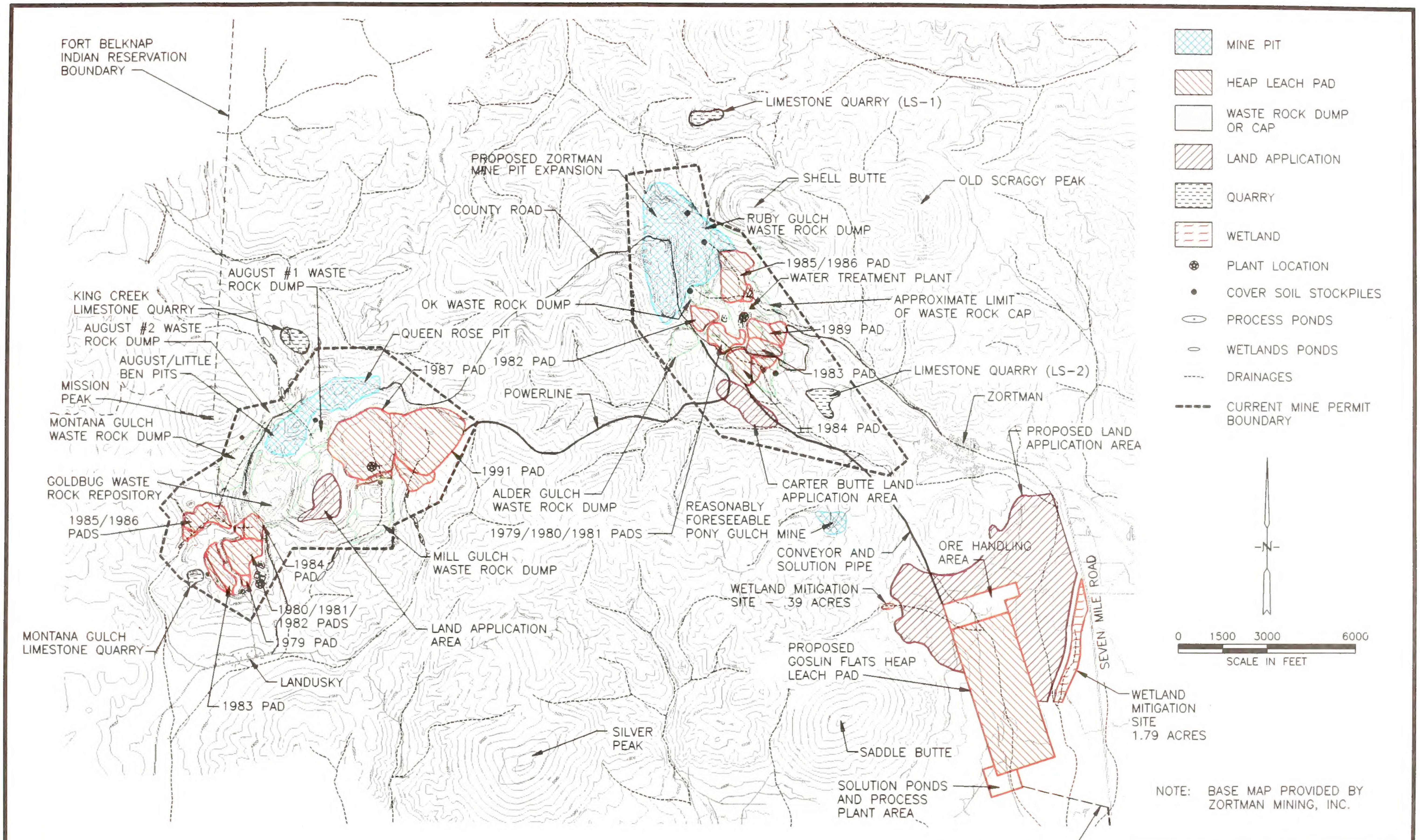
The location and currently permitted area of the Zortman Mine and the proposed Mine expansion with development of the waste rock repository on existing facilities are shown on Figure 2.11-1 and Exhibit 1, located in the map pocket of this document. Ore production would be approximately 60,000 to 80,000 tons per day, with mining and leaching operations performed on a year-round basis. The total new disturbance for the Zortman expansion would be approximately 1,155 acres, including buffer zones around disturbance and 405 acres previously disturbed under the existing permit.

ZMI has proposed several changes to current operations at the Landusky Mine, including provisions for mining an additional 7.6 million tons of ore and 7 million tons of waste rock. The quantity of ore to be mined under this application would constitute slightly less than one year of additional mining at the facility. Service facilities to support these operations would include a limestone quarry developed within the current permit boundary. The location of the currently permitted mine area and proposed Landusky Mine facilities under this alternative are shown on Figure 2.11-1 and Exhibit 2, located in the map pocket of this document.

Under this alternative ZMI would continue to use open-pit mining and heap-leach mineral processing to extract gold and silver from ore, as described in Section 2.8.1. This alternative includes little variation for Landusky Mine operations from Alternative 4 other than water capture and control systems. Additional detail is provided where a modification from the CPA is included. The major operational modifications from the CPA include:

- To limit the area of disturbance, the new waste rock repository at the Zortman Mine would be constructed mostly on existing facilities around the Zortman pit complex, rather than in Carter Gulch.

- To avoid impacts to the Lodgepole Creek drainage limestone for use in construction and reclamation at the Zortman Mine facilities would be quarried at the LS-2 site.



ALTERNATIVE 7: MAJOR NEW FACILITIES INCLUDE THE GOSLIN FLATS HEAP LEACH PAD, THE WASTE ROCK CAP, AND THE ZORTMAN MINE PIT EXPANSION

ALTERNATIVE 7
ZORTMAN-LANDUSKY EXISTING AND PROPOSED FACILITY LOCATIONS

ZLF-ALT7

FIG. 2.11-1

- To avoid impacts to the King Creek drainage limestone for use in construction and reclamation at the Landusky Mine facilities would be quarried at the Montana Gulch site.

Mining and related operations would take place 7 days a week, 24 hours per day, 350 days per year. ZMI projects that the CPA work force would be similar to current operations, with approximately 260-280 full-time employees, depending on seasonal requirements. Modifications to the mine expansions should not substantively change the rate of operations or the work force.

2.11.1.1 Mine Pit Expansion

Pit expansion at either mine would not change from that described in Alternative 4, Section 2.8.1.1. The edges of the Zortman Mine pit would be extended outward 600 or more feet from the current pit configuration. The pit would be deepened approximately 500 feet in some ore zones, to a lowest point of about 4,500 feet. A plan view of the pit complex was shown on Figure 2.8-3, with pit cross-sections displayed in Figures 2.8-4 and 2.8-5.

The Zortman Mine pit expansion would encompass a portion of the 85/86 leach pad area. This leach pad and dike would be covered by the new waste rock repository and enhanced reclamation covers. Some spent ore from the leach pad would be off-loaded and placed on a lined area of the new waste rock repository.

The proposed expansion for the Landusky Mine would involve lateral and vertical expansion of the Queen Rose/Suprise and August/Little Ben pits, and the South Gold Bug pit, which is an extension of the existing Gold Bug Pit. A plan view of the ultimate pit complex was shown on Figure 2.8-6, with typical cross sections of the pit expansions in Figures 2.8-7 and 2.8-8.

Mining Methods

Material would be mined from previously permitted and expanded pit areas. An overall 0.68:1 to 0.75:1 waste/ore stripping ratio is expected at the Zortman Mine. Mine operations associated with the expanded ore body would follow conventional open pit methods presently used. Ore would be mined via drill, blast and transport methods using haul trucks, loaders and shovels. Blasting would be accomplished using rotary drills with holes drilled on approximately 13' by 13' centers. A mixture of (ANFO) would be used as the main blasting agent.

After blasting, oxidized ore would be loaded onto haul trucks and transported to a primary crusher, located at the crushing area near the pit. After an initial crushing, the ore would be transported via a conveyor system to a stockpile adjacent to the heap leach operation. Unoxidized ore would also pass through the primary crusher and be conveyed to a separate stockpile. The crushed unoxidized ore would pass through secondary and tertiary crushing in an enclosed facility near the leach pad.

At the Landusky Mine, ZMI proposes to mine an additional 7.6 million tons of ore and 7 million tons of waste rock from the Landusky operation beyond that which is currently permitted. No new lateral disturbance is associated with the Queen Rose/Suprise and August/Little Ben pits since expansion would occur within the existing pit outlines. Ore would be loaded by truck on the existing 87/91 leach pad. End of mine life, based on current permitted leach pad capacity for the 87/91 leach pad, is estimated to be early 1996. Permitting of the proposed 7.6 million ore tons would extend the mine life by approximately one year.

Mining would be conducted using ZMI personnel and a fleet of 12 to 16 Caterpillar 777B haul trucks (or similar equipment), 10 to 12 diesel powered support vehicles (bulldozers, loaders, road graders and shovels), and 25 to 40 gasoline and propane powered service and utility vehicles. Contractors could provide additional services that might increase totals in each of the above equipment categories by as much as 50 percent. Mine operations are scheduled for 24 hours per day, seven days per week. Total ore and waste rock mined per day would be approximately 60 to 80 thousands tons.

Rock Characterization

The materials and their relative amounts to be mined during expanded operations at the two mines were described in Alternative 4, Section 2.8.1.1. The geochemical sampling and waste rock characterization program proposed by ZMI, and described in Section 2.8.1.1, would be implemented under this alternative with the mitigations that have been added restricting the use of certain waste rock types in reclamation, as described in Section 2.11.2.

Waste Rock Handling

Waste rock generated at the two mines would be handled according to its potential to create acid. Waste rock known to be acid generating would be placed in the center of the waste rock repository. The mine pit complex would have a bottom layer of non-acid generating (NAG), acid-buffering material, and be capped to reduce infiltration and contact with the waste rock. Waste rock placed into the interval of the pits which would have a fluctuating water table must be non-

acid forming, as defined by the criteria described in Section 2.11.2. Waste rock placed below the zone of fluctuating water table (i.e., in the bottom portions of the pits which would always be saturated) must have a sulfur content less than 0.5 percent. Non-acid forming waste rock would be stockpiled for use in reclamation or used immediately as cover and encapsulation material on existing facilities needing reclamation, such as leach pads.

Waste rock could not be used in the construction of reclamation covers based solely on the sulfur content of the rock. Material used in construction purposes and as a capillary break must meet the geochemical and lithologic criteria described in Section 2.11.2.

2.11.1.2 Crushing Operation

Metallurgical testing at the Zortman Mine has shown that unoxidized ore must be crushed to facilitate gold recovery. Crushing reduces the size of individual ore fragments, thereby increasing the surface area upon which the heap leach chemicals will act to separate gold from the rock matrix. Figure 2.8-2, shown earlier in the description of the Company Proposed Action, illustrates the crushing systems and other processes used to move ore from the pit and prepare it for leaching. A brief description of the crushing procedure follows.

Ore would be hauled from the mine pit in trucks and placed in a truck dump hopper, located at the crushing area near the pit. In the event the hopper or conveyor system are inoperable, the ore would be placed in a stockpile adjacent to the primary crusher. Oxide ore would be crushed to less than 6 inches in diameter by a primary crusher, then conveyed to a mixed ore (both oxidized and unoxidized ore) stockpile located near the Goslin Flats leach pad. Unoxidized ore would also be processed through the primary crusher, and then pass through additional crushing mechanisms in an enclosed facility near the leach pad. The unoxidized ore requires additional crushing since it needs to be in smaller fragments than the oxide ore for the leaching process to extract gold and silver.

Unoxidized ore would be placed in a coarse ore stockpile near the leach pad and fed into the secondary and tertiary crushing mechanisms. These crushers would be located in two buildings connected by conveyors. The secondary and tertiary crushers would operate continuously with a pass-through rate of approximately 1,000 tons/hour, although up to 2,000 tons/hour could be processed if necessary. The crushed, unoxidized ore coming out of the tertiary crusher would be fed into either the mixed ore stockpile or placed in a third stockpile containing only crushed, unoxidized ore.

Therefore, three stockpiles would be developed near the Goslin Flats leach pad to hold ore. The mixed ore stockpile, with an 87,500-ton capacity, would contain approximately 70 percent oxide ore and up to 30 percent crushed unoxidized ore. The remaining crushed unoxidized ore would be placed in a second stockpile with a capacity of 19,400 tons. Both the mixed ore stockpile and the crushed unoxidized ore stockpile would be used to hold ore pending transport to the heap leach pad. The third stockpile, with a capacity of 68,100 tons, would be used to hold coarse (only crushed once in the primary crusher) unoxidized ore pending additional crushing. The crushing facilities and ore stockpiles by the leach pad would encompass about 22 acres of disturbance.

The truck dump, primary crusher, and ore stockpile area adjacent to the mine pit would be illuminated using mercury vapor or similar type bulbs directed downward from dusk to daylight, seven days per week. Six to eight lights fixed 15 to 40 feet above ground level would be required in this area. The ore stockpiles and secondary and tertiary crusher areas near the leach pad would be illuminated using mercury vapor or similar type bulbs directed downward from dusk to daylight, seven days per week. Five to eight lights fixed 15 to 40 feet above ground level would be required in this area.

Mining of the deeper portions of the Queen Rose/Suprise, August/Little Ben, or expanded South Gold Bug pits at the Landusky Mine would not require crushing or special handling for leaching purposes.

2.11.1.3 Conveyor System

An overland conveyor system would be used to connect Zortman Mine operations at the open pit complex with the heap leaching facilities at Goslin Flats. As illustrated on Figure 2.11-1, the conveyor would originate near the 84 leach pad, travel southeast through Alder Gulch, and enter Goslin Flats through the gap just west of Whitcomb Butte.

The overland conveyor would be about 12,000 feet long with an elevation drop of about 1,000 feet. The conveyor would, in most areas, be 5.5 feet from ground level to the top of the dust-control covers at the two transfer points, and have approximately 2 feet of clearance below the bottom belt. Six bridge sections are proposed that would have bridge heights ranging from 9 to 90 feet. Spans would range from 15 feet to 650 feet.

The conveyor belt would be approximately 42 inches wide with dust-control covers placed at the ore transfer points near the primary crusher and at the stockpiles near the secondary and tertiary crushers (the Air Quality Permit, in DEQ files, contains a description of proposed dust suppression measures on the conveyor and other mine facilities). The conveyor would travel at about 800 feet per minute with a design capacity of approximately 2,000 tons per hour. The conveyor would generate 1200 kV of power, which would be sent back into the local utility power grid. A roadway would be constructed along the conveyor route, where possible, for maintenance access. A 200-foot corridor with an average disturbance of 50 feet would be required for the conveyor and roadway.

The conveyor corridor would be fenced with four strand barbed-wire to limit public access. Security patrols of the corridor would further minimize public access to conveyor facilities. Public access to the southern range of the Little Rocky Mountains through Pony Gulch would be maintained. Due to the steep terrain involved on the route, fencing would not be possible the entire length of the conveyor.

Lighting would be provided by mercury vapor or similar type bulbs spaced every 15 feet, affixed 3 to 5 feet above the conveyor belt. The overland conveyor would be illuminated at two transfer points, one near the primary crusher by the mine and the other near the ore splitter adjacent to the ore stockpiles. Lighting would be provided by mercury vapor or similar type bulbs directed downward dusk to daylight, seven days per week. Two to four lights located 15 to 40 feet above ground would be required at each transfer point. Lighting would also be required from the mixed ore and crushed unoxidized feed conveyors to the stacker from dusk to daylight, seven days per week.

An emergency surge hopper would be placed at the end of the overland conveyor near the heap leach pad site. This hopper would be used to contain material discharged from the overland conveyor during any abnormal conveyor stoppage.

Transfer conveyors would feed material to the self propelled stacker on the heap leach pad. Lime for pH control and barren process solution for dust control would be added to the material on the transfer conveyors. Areas where barren process solution is added would be lined with drainage directed toward the pad or solution capture system. Blended ore would be stacked onto the leach pad in multiple lifts using the self propelled stacker operating on top of the heap. The heap stacking process would be repeated until the maximum capacity of the heap leach pad is reached.

Ore from the Landusky Mine would be transported by truck to the heap leach pad. No other ore conveyor system would be required.

2.11.1.4 Heap Leach Pads

Goslin Flats

The heap leaching facility would not change significantly from that described in Alternative 4. Section 2.8.1.4 describes the leach pad construction and operation, solution management, operation of the processing plant, and handling of reagents. Figures 2.8-10 and 2.8-11 in the description of the Company Proposed Action illustrate the heap leach pad design from plan and cross-sectional views, respectively.

The Thermopolis Shale could not be used in construction or reclamation activities without demonstration of NAG character. Filter drains would have to be constructed using native calcareous subsoil or unmineralized carbonates.

ZMI would retain a professional engineer or engineering company as an independent inspector to monitor leach pad construction. This inspector would be responsible for monitoring and reporting on all phases of construction to assure that design specifications are met, and that field modifications are justified and summarized. The inspector would perform or oversee material inspections and compaction tests, including tests on fill material and the soil liner, permeability tests on the soil liner, strength tests of the soil liner, and grain size analysis of solution drain material. The inspector would also prepare daily reports. An as-built report and drawings of the facility would be submitted to the agencies for review.

An independent third-party engineering firm would monitor and oversee installation of the synthetic liner, including deployment of the liner to the site. Liner panels would have a minimum overlap of 6 inches and be welded together with an adhesive-bodied solvent on a clean seaming surface. All field seams would be tested using a 30-psi air lance along the entire seam. Where air pockets or riffles are observed, they would be marked, repaired, and air lanced again to ensure proper bonding. The entire liner area would be inspected. Wrinkles, punctures, or defects that may be detected would be repaired and tested in order to ensure proper bonding. Additionally, seam analysis samples would be collected and sent to a certified laboratory for peel adhesion and bonded seam strength (shear) to confirm

field testing and observation. An as-built report and drawings of the facility would be submitted to the agencies for review.

87/91 Leach Pad

The 87/91 leach pad was developed by expanding the 87 leach pad to the east and the 91 leach pad to the west, for one combined unit. This leach pad has already been permitted and constructed. The 7.6 million tons of ore proposed to be mined under this expansion would be placed on the existing 87/91 leach pad. No new construction of either lined pad area or buttress is required or proposed; expansion of the pad would occur by increasing the vertical loading of ore on the pad. The final pad capacity on this facility would be increased from the current 101.9 million tons to 109.5 million tons, and the final elevation at completion would be 5,450 feet, an increase in elevation of approximately 50 feet. There are no changes in lateral disturbance which are associated with the increase in loading of this pad to 109.5 million tons. However, there would be lateral modification associated with slope reduction undertaken during reclamation.

Zortman Mine Solution Management

Figure 2.8-10 in the Company Proposed Action shows the location of the processing facilities, including the process plant and ponds to collect, store, and control processing solutions. No discharge of solution entering the processing facilities is proposed as part of the normal operations, other than that solution which enters the atmosphere as evaporate.

Solution at the Goslin Flats leach pad would be stored within the heap, in the pore space of the ore in the sumps and behind dikes, or in surface ponds. The volume of solution required for ore processing would be maintained by adding makeup water during periods of net solution deficit (i.e., dry months), and by temporarily storing solution during periods of net solution surplus (i.e., higher precipitation months). The average external makeup water rate is expected to be 140 gallons per minute.

Pond Capacity - The barren and pregnant solution ponds would be sized to store approximately one day's maximum anticipated process plant requirements plus one million gallons contingency. Based on a maximum process flow rate of 3,500 gallons per minute, the barren and pregnant ponds would be sized to retain approximately 6 million gallons each.

The total in-heap storage capacity is approximately 30 million gallons, with 14 million gallons impounded by the middle dike and 15 million gallons in the south dikes and their associated sumps. The contingency ponds have been sized to store a total of approximately 38 million gallons of solution. In total, the system (barren, pregnant and contingency ponds, and middle and south dike retention ponds) would have a solution storage capacity of approximately 80 million gallons.

Heap Draindown - Heap draindown is the process through which the moisture content of the ore at the time leaching is conducted is reduced to an amount which the ore can retain after leaching stops. This reduction in moisture content adds free solution to the system, thereby increasing storage requirements and reducing storage capacity. A certain amount of operational draindown occurs through the heap leaching process, as active leaching advances from one portion of the ore heap to another, thereby isolating some ore from the active leach cycle.

It is possible that a heap leach facility's solution pumps could become inoperable, thereby removing some or all of the ore being leached from the active leach cycle. In such instances, excess solution drains from the ore. This circumstance is known as emergency draindown. Should an emergency draindown occur during the design storm event (6.33-inch, 24-hour), excess solution would accumulate at the rate of approximately 1.4 million gallons per hour. The Goslin Flats leach pad would be designed to accommodate a design storm and pump shutdown duration of 36 hours.

Solution Pipeline - A 10-inch steel, Schedule 40 grade B pipeline, double-lined with a 12-inch ADS pipe, would be constructed along the conveyor route. The pipeline would transport excess, weak cyanide solution of less than 25 mg/l WAD from the existing Zortman and Landusky mine facilities down to the Goslin Flats process plant where it can be used in the process circuit (see Figure 2.11-1 for pipeline route). Additional information concerning the use of weak cyanide solution can be found in Section 2.8.2.4.

The pipeline would be placed next to the conveyor line on the cut side of the maintenance roadway where underlying material is very competent. The double-lined pipe would follow the conveyor route on the roadway and over bridges, including the Alder Gulch crossing at a constant grade. Flow monitoring in the pipeline would be accomplished through the use of pressure or flow sensors that would automatically activate valve closures and pump shutdown, in the event pressure or flow fluctuated above or below a normal operating range due to leakage or rupture of the steel pipeline. The double-lined pipeline would convey leakage, if present, into the lined process ponds at Goslin Flats.

Landusky Mine Solution Management

No additional solution ponds are proposed in connection with the proposed additional ore and waste rock mining at the Landusky Mine.

Processing Plant Operations

At the Zortman Mine, a plant encompassing approximately 23 acres (including ponds) would be constructed at the southwest toe of the leach pad where solution from the pregnant pond would be processed to extract gold and silver. Five columns filled with activated carbon would collect the metals through an adsorption process, which means the metals would drop out of solution by fixing to the carbon particles. An average flow of 2,500 gpm of pregnant solution would pass through the columns, although the plant would be sized to handle up to 3,500 gpm. Pregnant solution would enter the first carbon column from the bottom, contact carbon as it proceeds upward, and overflow into a collection system where it would gravity-feed into the next column. Flow would continue in this way through all five columns, and exit the last column as barren solution. Eventually carbon in the first column would reach a maximum loading and the carbon would not be able to adsorb any more metals. When this occurs, the "loaded" carbon from the first column would be transferred to the carbon stripping circuit, described below.

Precious metals would be removed from each batch of loaded carbon in the stripping system. In this process, the temperature and pressure are elevated to about 210°F and 15 psi, respectively. A caustic solution is introduced into the carbon which strips the metal from the carbon. After gold and silver have been removed from the carbon, the solution would be pumped through an electrolytic cell. A current running through this cell transfers or "plates" the metals onto steel wool cathodes. The cathodes would then be sent to the refinery, mixed with a flux, and smelted in a furnace to produce dore. The dore would be stored until shipment to a commercial refinery for furthering purification.

ZMI expects to collect about four tons of "loaded" or metal-laden carbon per day of operation. The carbon can be reused after the metals have been stripped, but after repeated cycles impurities build up on the carbon which cannot be completely removed by acid washing and elution. These impurities reduce the ability of the carbon to adsorb metals. To regain this capacity, the carbon would be reactivated by heating in the presence of steam in a slightly oxidizing atmosphere. Wet carbon would be loaded into a rotary gas-fired reactivation kiln where it would be heated to about 1300°F. This process would oxidize organic impurities in the carbon and create new micro-pores to restore most of the adsorption capability.

The processing plant yard and pregnant, barren, and contingency pond areas would be illuminated using mercury vapor or similar type bulbs directed downward from dusk to daylight, seven days per week. Lighting would be spaced every 25 to 50 feet, 15 to 40 feet above the ground. Approximately 15 to 20 lights would be required in the process plant and pond area.

At the Landusky Mine, no change is proposed in operation of the processing plant. The existing facilities would continue to be used to process gold bearing solutions from the leach pads. There would be no changes in reagent handling and storage.

Leak Detection System

Underdrain seepage detection systems and shallow groundwater wells adjacent to the Goslin Flats leach pad would monitor for process solution leaks. No additional change is proposed to the leak detection system, as described in Section 2.5.1.3, Alternative 1. The existing underdrains and monitoring wells that are beneath and adjacent to the 87 and 91 leach pads would be used to monitor for process solution leakage.

Reagent Handling

Major reagents, including cyanide for leaching and lime for pH control, are proposed to be consumed at a rate of approximately 1 lb. and 4-8 lbs/ton of ore, respectively. Lime in the form of calcium oxide would be shipped at a rate of approximately 5 trucks per day, with an annual usage of approximately 36,000 tons per year. Lime would be stored in silos near the leach pad. Cyanide, in the form of sodium cyanide, would be brought in at a rate of one truck every other day with an annual usage of approximately 6,000 tons per year. Sodium cyanide used in ore leaching would be mixed in an agitation tank at the processing plant. Barrels of dry cyanide are also used in the carbon strip plant. The estimated annual use is approximately 82 tons per year.

Because cyanide is a potentially toxic compound, ZMI has prepared a contingency plan in the event of a cyanide spill at the Zortman or Landusky mines. This plan contains information on spill discovery, notification, containment, neutralization, cleanup and reporting (ZMI August 1991). Calcium hypochlorite would be used to neutralize spilled cyanide solution where the spill pH is greater than 10 and the cyanide concentration is less than 500 mg/l. If the pH is less than 10 or the cyanide is in a concentrated solution, lime would first be added to raise pH and dilute the concentration. Dry or highly concentrated cyanide solutions would never be treated

with calcium hypochlorite due to the potential formation of cyanogen chloride (a toxic gas), and if water comes in contact with dry cyanide, hydrogen cyanide gas could be released. Dry cyanide spills would be swept or shoveled into containers by cleanup personnel wearing suitable protective equipment. The material could then be disposed into the barren pond. The ore processing facilities are designed to contain all spills within the buildings with a drain trench connected to the process ponds. The ore processing building would have a containment curb sized to hold at least the solution capacity of the carbon columns and holding tanks.

More information on the use of chemicals in mining and ore processing operations is found in Sections 2.11.1.6 and 3.14, Hazardous Materials.

2.11.1.5 Waste Rock Repositories

Zortman Mine

The waste rock repository would be constructed on top of existing facilities at the Zortman Mine site. Use of this area and the pit complex for waste rock storage would serve two principle purposes. First, disturbance for waste rock storage would largely be limited to areas and facilities already disturbed by mining activities. Second, the waste rock repository would serve a dual role as a cap on top of existing facilities which require re-reclamation or better cover from surface water infiltration.

Approximately 250 acres would be necessary for pit recontouring and construction of the waste rock cap. The waste rock cap would be designed to contain a maximum of 60 million tons of waste rock, the amount anticipated to be generated during expanded mining activities. However, about 20 million tons of this waste rock would be backfilled into the pit complex.

Concurrent with construction of the new waste rock repository, ZMI would remove the approximately 3.4 million tons of waste rock from the existing Alder Gulch waste rock dump. The existing material in Alder Gulch is seeping poor quality water from the toe of the dump, and removal of the material would reduce impacts to the drainage. This material would be relocated to the leach pad at Goslin Flats for processing as ore.

Configuration of the waste rock repository and cap at the Zortman Mine is shown on Figures 2.11-2 and 2.11-3. The waste rock cap would be constructed with a 3H:1V overall slope, with 15-foot wide benches every 100 vertical feet. Benches would be backsloped and drain toward common surface water diversion ditches built along the edges of the facility.

The waste rock repository would be constructed over existing facilities at the Zortman Mine which may not have been designed to hold large quantities of additional overburden (the waste rock cap thickness would extend up to 370 feet in the area of the backfilled Ross Pit). To minimize settlement, the waste cap would be placed in lifts ranging in thickness from 5 to 25 feet. In areas where differential settlement may occur, such as between existing heaps, waste rock would be placed in 5 foot lifts.

The toe of the waste rock repository would extend from the Alder Spur drainage elevation, about 4,420 feet above mean sea level, to a maximum elevation of 5,220 feet east of the mine pit. The toe of the waste rock repository in the Ruby Gulch drainage would be located at an approximate elevation of 4,500 feet above mean sea level.

Landusky Mine

As described in the CPA, Section 2.8.1.4 about 7 million additional tons of waste rock would be mined and scheduled for disposal in the Gold Bug waste repository or backfilled in the Queen Rose pit. The nominal slope of the repository would be built at 3H:1V, and drainage benches (25 feet wide) would be placed every 100 vertical feet. Reclamation at the Gold Bug would continue to occur concurrent with mining activities. Section 2.11.2.4 provides more information on the repository reclamation programs.

2.11.1.6 Other Features and Facilities

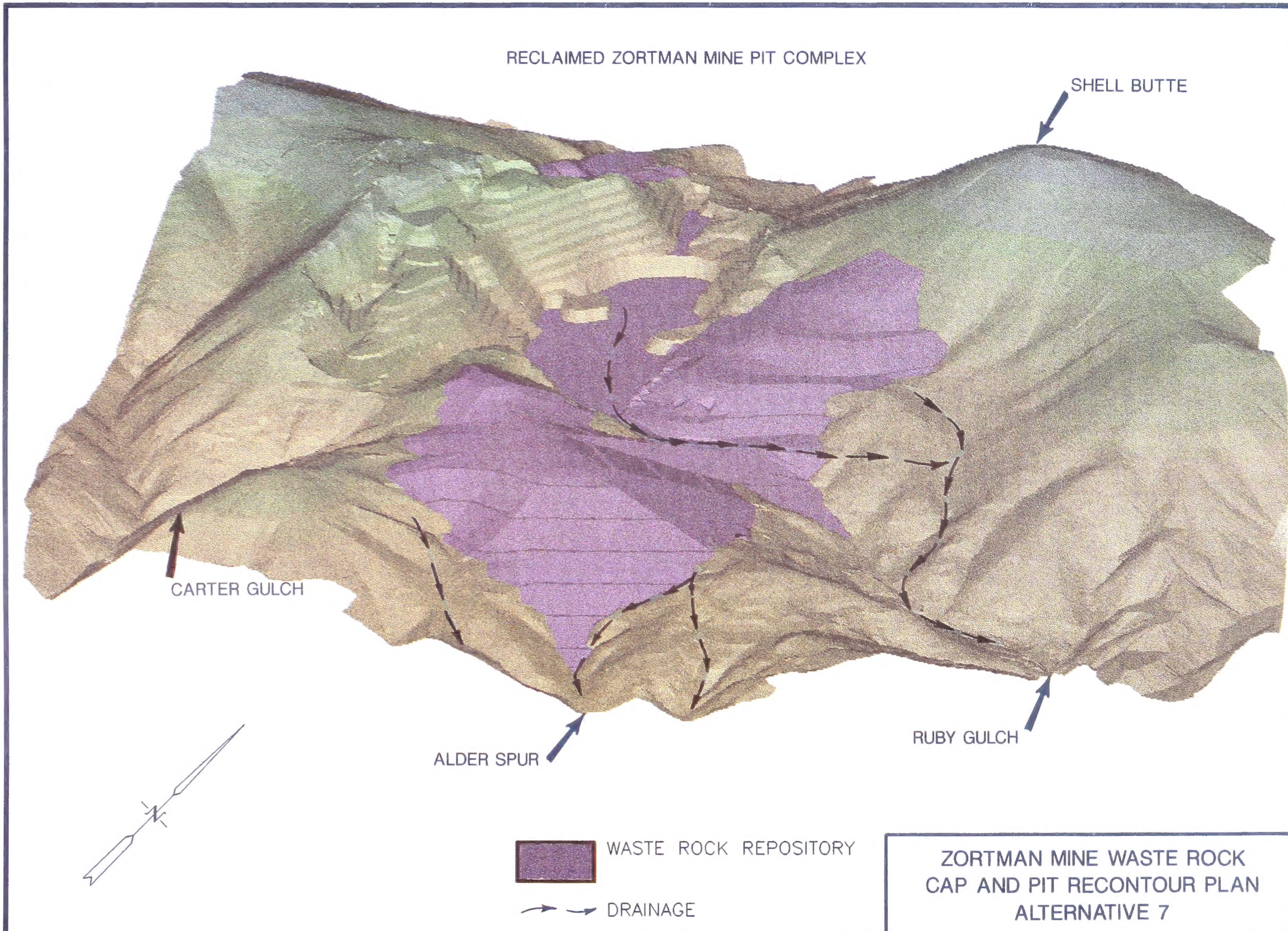
The following sections describe other facilities and mine features. Where appropriate and when no change is expected from current permit conditions, information is summarized from Section 2.5.1.5.

Office/Laboratory Facilities

The main office building for ZMI is located in the town of Zortman. The production assay lab is located across the street from the main office in a separate building. The laboratory and office functions would continue as described in Alternative 1, Section 2.5.1.5.

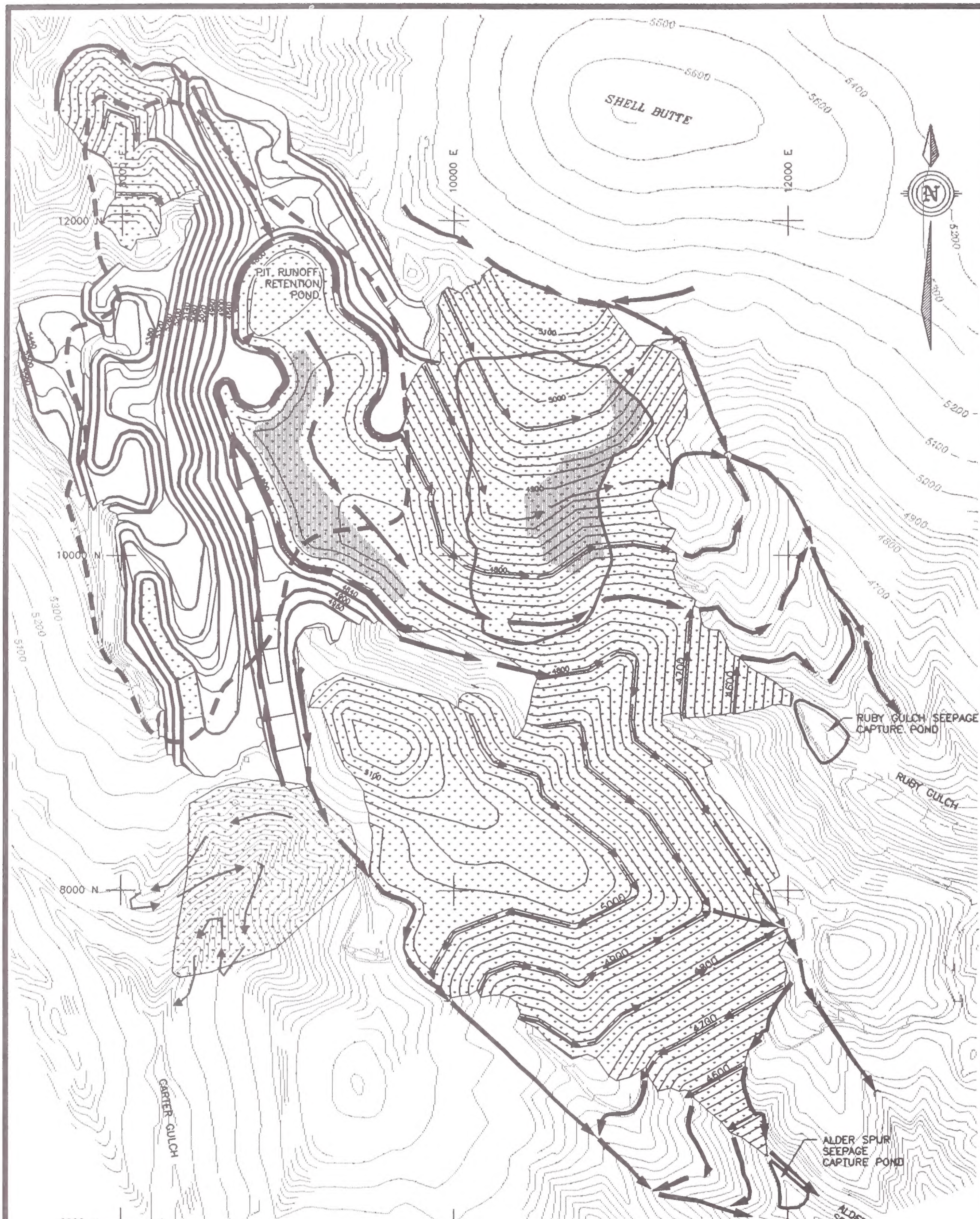
Access and Haul Roads

A road network map was presented on Figure 2.5-2 of Alternative 1, showing access and haul roads that would be active during the mining operation. A brief description of roadways follows.



ZORTMAN MINE WASTE ROCK
CAP AND PIT RECONTOUR PLAN
ALTERNATIVE 7

FIG. 2.11–2



Current Pit Boundary

85/86 Leach Pad Edge of Liner

General Flow Direction

Spent Ore Placement

Reclamation

ALTERNATIVE 7
WASTE ROCK CAP, POST RECLAMATION TOPOGRAPHY AND DRAINAGE

<u>Access Roads</u> - The Zortman to Landusky road would be re-routed due to the expansion of the mine pit. Access road grades are designed to be 10 percent or less. Access road construction techniques for the proposed leach pad would be the same as access roads in the presently permitted areas. Access roads would be constructed using balanced cut-and-fill methods and are proposed to be approximately 30 to 50-feet wide where needed. Road beds would be compacted with construction equipment and topped with coarse gravel or fine oxide waste material. All roads would be sloped to allow for drainage away from the pad and waste rock storage areas. Drainage would be provided by sloping the roads as they are constructed so the drain ditches would handle runoff. Also, a berm would be placed on the outside edge of the road. Access roads would not cross any major drainages so culverts are not expected to be necessary. In the event that it becomes necessary, ZMI would install the required culverts to prevent erosion and channeling problems.

All access roads would be maintained as required for traffic, with road graders used as the primary maintenance equipment. All roads would be maintained throughout the life-of-mine.

<u>Haul Roads</u> - At the Zortman Mine, haul roads would be constructed to allow a 70-foot running width from the inside edge to the inside toe of the safety berm. All haul roads would be constructed on the daylight edge of the pit, which is the lowest area on the pit perimeter. Haul roads would be left on the margin of the waste rock cap after installation of the final reclamation cover, to facilitate reclamation and closure monitoring. A haul road would not be constructed or developed to the LS-1 limestone quarry, since this alternative requires the use of the LS-2 limestone source located within the existing mine permit boundary (see Section 2.11.2.1).

At the Landusky Mine, a haul road would be constructed in the permitted disturbance area for accessing the South Gold Bug Pit area. Existing access and haul roads would be used and new roads may be constructed on existing disturbed areas within the pits. The haul road to the King Creek quarry would not be widened, however, since this alternative requires the use of the Montana Gulch limestone source for reclamation materials (see Section 2.11.2.1).

Power and Water Supply

Power for the expanded operations at the Zortman and Landusky mines would be provided from the existing Big Flat Electric Cooperative lines into Zortman and Landusky. At the Zortman Mine, power requirements for the mine expansion and ore processing facilities would be supplemented by connecting the power supply at the Landusky Mine with the Zortman Mine. This would allow for any additional power needed at one operation to be allocated from the other. The powerline would be buried and follow the approximate route shown in Figure 2.11-1. An overhead power line would be erected adjacent to the access road connecting the county road with the ore handling area. An overhead power line would also be run from the county road to the process plant and pond area across Ruby Creek.

The ore and waste rock conveyor would generate up to 1,200 kW when running fully loaded. However, the primary source of power would come from the existing Big Flat Electric Cooperative power lines. This existing power system would provide sufficient power to start the conveyor motor while the Zortman and Landusky leaching and processing motors and equipment are operating, without overloading the line (ZMI 1995). The regenerated power from the overland conveyor would be used to start the primary, secondary, and tertiary crushing motors. Both the existing line power and regenerated power would be used to operate conveying, crushing, leaching, processing and ancillary facilities when all systems are operating.

The maximum power draw occurs when a motor is being started. A programmed logic circuit would be installed by ZMI so the overland conveyor motor and crushing motors cannot be started at the same time. In the event the secondary and tertiary crusher motors are operating while the conveyor is down, sufficient line power would be available to run them. However, it would be necessary to shut down the secondary and tertiary crusher motors in order to start the primary crusher and overland conveyor, then restart the secondary and tertiary crusher motors when regenerative power is available from the conveyor (ZMI 1995).

An average water supply of 190 gpm would be obtained from groundwater wells for the expansion. ZMI has an appropriation from the Department of Natural Resources and Conservation to obtain this makeup water, using supply wells ZL-102 and ZL-163 (see Exhibit 1). Peak water requirements from pumped groundwater are expected during winter months when less effective precipitation is received. Estimated average volume requirements for specific purposes include 140 gpm for ore-wetting and evaporative losses

from the processing circuit, and 50 gpm for road dust control.

No changes are proposed in the current power and water supply systems for the Landusky Mine. Electrical power is obtained from the Landusky grid, which is supplied by the Big Flat Power Cooperative through an existing 23 kV line. Potable water is obtained from groundwater wells. Process water is obtained from precipitation and groundwater appropriation.

Sewage Treatment

At the Zortman Mine, an additional septic treatment facility with a drainfield would be placed at the Goslin Flats process plant. Six full-time employees are expected to work at the plant. A standard 1000-gallon, precast concrete, two compartment septic tank would be used. The drainfield would be designed to EPA standards. The septic system would be installed by licensed and certified contractors.

At the Landusky Mine, no changes are proposed from the current septic waste treatment systems. See Section 2.5.1.5, Alternative 1, for additional information.

Chemical Use

A variety of chemicals and potentially hazardous compounds would be needed for mining, ore processing, and reclamation activities at the Zortman Mine. Some of these compounds have been described in Alternative 1, Section 2.5.1.7. This section identifies the potentially hazardous materials and their projected use at the Zortman Mine. A discussion of the hazardous material usage, storage, handling, consumption, and waste disposal is presented in Section 3.14. The chemicals and their rate of use would be similar to historic uses, except that lime would replace sodium hydroxide for pH control, and the amount of flocculent would decrease.

Compound	Estimated Use
Lime	36,000 ton/yr
Sodium Cyanide	6,000 ton/yr
Gasoline	60,000 gal/yr
Hydrochloric Acid	33,000 gal/yr
Ca/Na Hypochlorite	Contingency use
Hydrogen Peroxide	Contingency use
Anti-Scalants	37,000 gal
Oil and Lubricants	40,000 gal/yr
Antifreeze	9,300 gal/yr
Flocculent	100 gal/yr
Citrus-base Solvent	800 gal/yr
Diesel Fuel	1.4 million gal/yr
ANFO	7,000 ton/yr

In addition, the following chemicals would also be used for the Zortman Mine expansion.

Sodium Hydroxide (caustic soda) is used in the stripping circuit to aid in desorption of gold and silver from the loaded carbon. The annual usage of caustic soda would be about 5,000 gallons.

Coagulant is used to settle small particles out of solution which can otherwise create problems in the clarifiers in the Merrill-Crowe plant. Since the new process ore processing system would rely solely on carbon adsorption, it is unknown how much coagulant would be needed to serve the same function in the carbon stripping circuit.

At the Landusky Mine, no changes are proposed from the current inventory and use of potentially hazardous materials. See Section 2.5.1.7, Alternative 1, for additional information.

Waste Disposal

No changes are proposed from the current disposal methods for solid and/or hazardous wastes at the two mines. See Section 3.14 for an expanded discussion of wastes produced and disposal methods.

2.11.1.7 Water Management

This section presents an overview of water management plans prepared by ZMI, with additional mitigating measures developed by the agencies, to mitigate impacts from existing and proposed expanded mining operations. It includes a description of measures that have been or would be implemented for management of process water, storm water and mine drainage. This section is divided into discussions on surface water runoff control, water capture, water treatment and LAD. Many of the water management measures proposed by ZMI in Alternative 4, Section 2.8.1.7, would apply to this alternative and are not repeated. Additional detail on measures to improve and maintain water quality are contained in the Water Quality Improvement Plan which is presented in Appendix A.

Objective: The objective under this and all other alternatives is to protect beneficial use and to achieve and maintain compliance with water quality standards.

Approach: This alternative relies on a combination of source control and active treatment to protect water quality. Mine waste is segregated and isolated based on acid generating potential. A combination of water balance and water barrier reclamation covers are used to limit infiltration of precipitation into mine waste,

thereby restricting water contact with potentially acid generating materials. Diversion of runon water is used to prevent stored acidity within the mine waste from being transported into adjacent surface or ground waters. Capture and treatment of impacted waters is required initially and used as a secondary measure in the long-term. The objective is to not rely on long-term water treatment to meet water quality standards.

The emphasis is to institute source controls to prevent contact of surface or ground waters with potentially acid generating materials. Modifications have been made to the reclamation covers which would increase their functional life, further restrict use of material with acid generating potential, limit soil erosion and sedimentation, and enhance revegetation. These measures are used to greatly reduce or perhaps eliminate the need for long-term water collection and treatment. The management of mine water requires keeping mine drainage, storm water and process waters segregated so that each can be handled using the technology most appropriate to each waters character.

Additional design measures have been incorporated in this alternative to facilitate water management. The design criteria for stormwater diversions would be increased to convey runoff resulting from the 6.33-inch, 24-hour storm event with 1-foot of freeboard.

The waste rock repository site would be relocated from the proposed Carter Gulch location. Instead the waste rock would be placed on existing leach pads and pit area at the Zortman Mine (Figure 2.11-2). This removes waste placement from close proximity to the Carter Gulch-Alder Gulch drainage system and generally facilitates water management.

Surface Water Runoff Control

With the exception of the new waste rock repository, most surface water runoff control features described in Alternative 4, Section 2.8.1.7 would apply to this alternative. All drainage and diversion ditches would have to be able to pass the peak flow from the 6.33-inch, 24-hour design storm event with 1 foot of freeboard as a safety measure.

Diversion channels would be trapezoidal or V shaped, lined with geotextile to prevent piping and rip-rapped with durable, non-acid forming rock sized for drainage area requirements. All diversion ditches would have road access for maintenance purposes. Maintenance would consist of removal of sediment load and repositioning of rip-rap as required. Sediment would be disposed of in the waste rock repository.

Mine Pits - At the Zortman Mine, the above pit diversions and pit floor drainage plans would be constructed as shown in Figure 2.11-2. A low permeability reclamation cover would be used on the pit floor to limit recharge to groundwater. All surface runoff from the mine pit floor/waste rock repository would be routed to drain to the south into Alder Spur and Ruby Gulch. The exiting 85/86 leach pad in Ruby Gulch would be covered with the new waste rock repository and enhanced reclamation covers.

The expanded mining would remove the majority of historic underground openings and mine workings from the Zortman Mine pits. Two haul adits connect workings to the surface, one daylighting north of the Ross pit in the Lodgepole drainage basin and one located to the southeast of the OK pit under the 85/86 leach pad in Ruby Gulch. To minimize oxygen flow and discharge of water from the workings, the adits would be sealed using concrete bulkheads prior to pit backfilling.

Diversions would be constructed at the Landusky Mine to route storm water away from pit disturbance limits. The pit bottoms would be backfilled to the 4,740-foot elevation at the south end with material removed from area drainages that are impacting water quality. Enhanced reclamation covers would be placed over the backfilled pit floor area to limit infiltration of precipitation through this material, thereby reducing recharge to the August drain tunnel which discharges beneath the Montana Gulch waste rock dump. The pit floor would be sloped to not impound runoff in the pit. A drainage cutout notch would be constructed across the bedrock divide between the August Pit and Montana Gulch. The channel would be sized to handle runoff from a 6.33 inch, 24-hour storm event. Runoff from the pit area would be routed through this channel and along the existing haul road route around the Montana Gulch Waste Rock Dump and 85/86 leach pad. The water would flow into settling/treatment ponds prior to discharging to Montana Gulch below the 85/86 leach pad.

Runoff from the pit highwalls at both mines may be of poor quality and constitute mine drainage. Portions of the pit walls that are potentially acid forming and cannot be capped would have diversions installed above the highwalls where access allows. These diversions would route storm water away from the pit highwalls. This flow would be captured in trenches at the highwall base and kept separate from storm water which falls on the pit floor. At the Landusky Mine, this flow would also be routed to Montana Gulch and treated, if necessary, prior to release. The diversions would be designed to be maintenance free to the extent possible and pass the

peak flow from a 6.33-inch storm event with one foot of freeboard. Highwalls and diversion structures would be visually inspected on a periodic basis and repairs made as necessary.

Leach Pads - Diversion ditches constructed around the leach pads to prevent the inflow of storm water would be upgraded to pass runoff from the 6.33-inch, 24-hour storm event.

At the Landusky Mine, a drainage trench would be excavated from the side of the west tributary of Montana Gulch that is blocked by the 85/86 leach pad. This would involve excavating approximately 36,000 tons of material with a disturbance of approximately one-quarter acre.

Waste Rock Repositories - At the Zortman Mine, the existing Alder Gulch waste rock dump would be removed and the dump footprint reclaimed. This would remove a current source of contamination from Carter Gulch.

The Alternative 7 waste rock repository would be constructed over the existing leach pads and the backfilled mine pit complex. The downstream ends of the repository would extend into Ruby Gulch and Alder Spur. Benches would be constructed on the repository slopes every 100 vertical feet to convey runoff to the main runoff ditches at the repository margins. These would discharge into Ruby and Alder drainages. Upgradient diversion channels would be constructed to prevent runon water from coming in contact with the waste rock. Figure 2.11-3 illustrates the drainage system and final reclamation topography.

No changes would be made to the present drainage control features for the Gold Bug and Mill Gulch waste repositories at the Landusky Mine. Portions of the Montana Gulch waste rock dump may be used for reclamation material or pit backfill. The remaining dump would have runoff controls installed adequate for the flow from the design storm event.

Water Capture

Ponds, diversions, slurry cut-off walls, and recovery wells would be used to capture mine drainage to prevent deterioration of water quality in adjacent drainages. Storm water would be segregated from mine drainage. Impacted water would not be released to surface water prior to treatment. Data would be collected in accordance with the monitoring plan to regularly monitor water quality and capture system effectiveness.

No changes would be made to most seepage water capture and treatment systems from those described in the CPA, Section 2.8.1.7. All seepage capture systems would be sized to handle seepage generated by the 6.33-inch, 24-hour storm event.

The Alder Spur capture system would be resized for seepage from the design event and moved downstream to immediately below the toe of the Alternative 7 waste rock repository. The existing capture system in Ruby Gulch would be used to capture impacted waters from the new waste rock repository. A new capture system would be constructed immediately downgradient of the Goslin Flats leach pad. This system would be available to capture post-reclamation seepage from the leach pad after liner perforation should discharge waters be contaminated by mine drainage or residual process chemicals.

All captured seepage water from Zortman Mine facilities would be pumped to the Zortman water treatment plant for treatment and release into Ruby Gulch. All captured seepage water from Landusky Mine facilities would be pumped to the new Landusky Mine water treatment plant for treatment and release into Montana Gulch.

All process ponds would be netted to eliminate wildlife exposure to potentially contaminated waters. All process solution ponds and catchment pond would be enclosed with 8-foot fencing capable of excluding big game and other large animals.

Seepage capture ponds and sumps would be inspected on a weekly basis for routine maintenance or repairs, if necessary. Additional information concerning the capture systems is found in the Water Quality Improvement Plan, Appendix A.

Water Treatment

ZMI constructed a 2,000-gpm water treatment plant in May 1994 to treat seepage water captured at the toe of existing mine waste rock dumps at the Zortman Mine. The plant operates at a rate of 200 to 2,000 gpm depending on factors such as precipitation amounts and seasonal operating conditions. This treatment plant would be relocated adjacent to the Ruby Gulch drainage downstream of the new waste rock repository.

Another water treatment plant is planned for the Landusky Mine and would be located in the Montana Gulch area. Additional information on the operation of the water treatment plants is contained in Appendix A.

The water treatment plant(s) would continue to operate until final reclamation measures have successfully produced effluent that meets the water quality standards. The use of enhanced reclamation covers may reduce or eliminate the need for long-term water capture and treatment to meet water quality objectives in many of the affected drainages. However, water capture and treatment would be needed in the short-term, and is assumed to be needed for the long-term. As water quality meets discharge standards and the appropriate agencies approve of release of the waters, capture ponds, sumps and pumpbacks systems would be dismantled and the sites reclaimed.

Land Application Disposal

Provisions for land application disposal are required for final heap draindown at mine closure, or in the case of an extreme precipitation event that overwhelms the capacity of the leaching circuit. In the land application process for this alternative leaching solutions are treated with hydrogen peroxide to detoxify the cyanide (hypochlorite treatment would not be allowed due to potential adverse impacts to vegetation). All solutions must be at or below 0.22 mg/l WAD cyanide prior to land application. Use of land application as a water management practice requires advanced notification and review by the regulatory agencies prior to each land application event to verify the character of the applied solutions, remaining soil attenuation capacity, and necessary monitoring techniques.

At the Zortman Mine, a total of 390 acres has been identified as suitable for use as a land application area while 285 acres near the Goslin Flats heap leach pad have been proposed for use as land application disposal sites during closure activities (see Figure 2.8-15 in the Company Proposed Action). ZMI identified the area near Goslin Flats as part of a field reconnaissance study to locate a candidate land application site. Soil samples were collected from the site, analyzed for chemistry, and tested using treated barren solution to determine the soil's ability to adsorb and attenuate metals and cyanide. The soil was also tested for hydraulic conductivity to evaluate solution migration to the subsurface. A solution balance was calculated to determine metal loading and solution application parameters. This study is documented in Volume 7, Appendix 27, of the Zortman Mine Permit Application (Schafer and Assoc. 1993a).

No operational land application disposal would be planned for this alternative. In the event that emergency land application of solutions is required, the land application area permitted for closure activities would be used. All neutralized effluents for disposal would have cyanide concentrations at or below 0.22 mg/l WAD. ZMI would notify the agencies prior to emergency land application. No emergency land application is anticipated during operations. In the unlikely event land application is required, it would be conducted as described in Alternative 1, Section 2.5.1.6 for currently permitted operations.

There would be minor disturbance to the land application area to gain access to solution pipelines. Solution pipelines would be removed and all disturbed areas would be reseeded.

Land application is not anticipated to be required for final heap draindown at the Landusky Mine. Draindown solution would be pumped to Goslin Flats leach pad and incorporated as process water. Solution containing less than 25 mg/l WAD cyanide would be piped from the Landusky Mine to the Zortman Mine via the pipeline adjacent to the Antoine Butte access road. It would then be transferred to the pipeline that would run adjacent to the conveyor and ultimately report to the process or contingency ponds at the Goslin Flats solution process plant.

2.11.2 Mitigated Mine Reclamation

The agencies have developed modifications to ZMI's proposed reclamation procedures which would: (1) reduce infiltration into areas with the potential to cause acidic drainage, (2) remove waste rock dumps and other sources currently causing degradation of surface water or groundwater, and (3) implement the Water Quality Improvement Plan to further mitigate effects of ARD should reclamation procedures fail to adequately protect water resources. Many of these reclamation modifications were described in detail in Section 2.7.2, for the Agency Mitigated Reclamation for Alternative 3. However, that alternative describes reclamation actions to be taken if ZMI's proposal for mine expansion is not approved. This alternative describes modified reclamation actions that would take place in conjunction with the mine expansion. The major reclamation modifications to be incorporated in this alternative include:

- To limit surface water infiltration and provide a better media for revegetation, water balance and water barrier reclamation covers would be used on the new waste rock repository, the new Goslin Flats leach pad, the 82 leach pad, expanded Gold Bug waste rock repository and other existing reclaimed or unreclaimed facilities.

- Unless specifically identified below, mine waste rock facilities and ore heaps are assumed to be acid generating and would be reclaimed using improved reclamation covers. To the extent possible, cover soil on existing facilities to be re-reclaimed would be removed, stockpiled, and reused.

- To enhance the probability of long-term reclamation success, soil loss from reclaimed areas must be less than 2 tons/acre/year.

- With the exception of most leach pad dikes, existing facilities would be reclaimed to an overall 3H:1V slope, with constructed benches for erosion control every 100 vertical feet between benches. This measure would reduce erosion and soil loss, increase overall surface reclamation success, and result in more stable facilities. In order to achieve the slope reductions while minimizing additional land disturbance in adjacent drainages, some material may have to be off-loaded from existing facilities and backfilled into the pit.

- In order to classify as "NAG" and be used without restriction in construction and reclamation, thereby ensuring the potentially acid generating materials are not placed in areas potentially exposed to surface water and the open atmosphere, waste rock to be used in reclamation/construction:

  1. Cannot be composed of breccia, felsic gneiss, monzonite, quartzite, or trachyte lithologies;

  2. If amphibolite, mafic gneiss, shale, dolomite or limestone must have a total sulfur content less than or equal to 0.8 percent, and a paste pH of 6.0 or greater;

  3. If syenite, must have a total sulfur content less than or equal to 0.2 percent, a paste pH of 6.5 or greater, and a NNP greater than 0;

  4. Must meet the criteria above as demonstrated by sampling and analyzing lithologies from every blasthole providing non-acid generating material for total sulfur, Paste pH and NP. All blastholes within a discrete mineable block (25 feet x 25 feet) must meet these criteria.

  5. If syenite, can only be used in reclamation covers and not for fill or other construction.

- To ensure that only NAG materials are used in facilities transporting surface water or seepage water, material used for capillary break/drainage layers may be obtained from the unmineralized sources specified in Section 2.11.2.1.

- Rock underdrains would be built with durable, unmineralized limestone as an additional precaution to buffer acidic drainage.

- No trees would be used in revegetation except on a limited basis for visual impact mitigation. Only grasses, forbs and shrubs would be used to enhance wildlife habitat. Crested wheatgrass would not be used in the reclamation seed mix.

- Vegetative cover must achieve 90 percent of that demonstrated in adjacent, natural communities of similar composition and location to be considered acceptable.

- An expanded monitoring program would be implemented, as described in Section 2.11.3, and reclamation viability would be monitored by ZMI until the agencies have approved final closure and released the mine reclamation bond.

- To the extent practicable, reclaimed facilities would be recontoured to provide a topography that blends into the surrounding landscape. Straight edges would be rounded. Large, flat surface areas would be broken with changes in contour resembling natural drainage patterns. The objective would be for the post-reclamation topography of the spent ore heaps to meet VRM Class II criteria. ZMI would submit recontouring plans to the agencies for review and comment prior to implementation.

Zortman Mine

- The mine pit complex would be backfilled to about the 4,800-foot level and graded so that runoff drains freely, without impoundment in the pit, into the Ruby Gulch drainage.

- The 89 leach pad dike would be tested for sulfur content as described in Section 2.8.2.2, and re-reclaimed if sulfur exceeds 0.5 percent in more than 10 percent of the material tested.

- The OK and Upper Alder Gulch waste rock dumps would be removed and used to backfill the pit complex, or leached to remove precious metals. Cover soil would be re-salvaged and the waste rock footprints reclaimed.

- The sulfide storage area in Ruby Gulch would also be removed and placed on the Goslin Flats leach pad for ore processing.

- The tailing in Ruby Gulch above the town of Zortman would be removed from the drainage and placed in the pit complex or used as reclamation or construction material. The drainage would be restored as mitigation for existing disturbance to waters of the United States by other Zortman and Landusky mines facilities.

- To reduce visual impacts observed from areas north of the mine, the north/northwest facing pit highwalls would be reduced to an overall 3:1 slope, with vertical faces reduced such that no slopes are steeper than 2:1.

<u>Landusky Mine</u>

- The Landusky 91 leach pad dike would be re-reclaimed to allow redistribution of spent ore to the south, west and east of the 87/91 pad. This action would eliminate the potential for surface water from the 87/91 pad to runoff north of the mine site into drainages on the Fort Belknap Reservation.

- Existing reclamation covers on the Gold Bug waste rock repository and the Mill Gulch waste rock dump may require supplemental cover soil to further reduce surface water infiltration.

- To unblock surface water drainage in the western tributary of Montana Gulch a drainage channel would be constructed along the west margin of the 85/86 leach pad.

- Highwall runoff would be diverted from the mine pits into Montana Gulch and treated if necessary.

- Backfill the Landusky Mine pits to a minimum elevation of 4,740 ft (at the south end of the pit complex/drainage ditch) to create a surface which would freely drain into Montana Gulch, thereby reducing the potential for precipitation and surface water runon to infiltrate through acidic materials and into the groundwater. Approximately 3.6 million tons of backfill would be required to reach this level. Material used in backfill would come from existing waste rock dumps and leach pads, mined waste rock, or construction of the drainage channel.

- Runoff from the Queen Rose/Suprise and August/Little Ben pit areas would be directed through a drainage notch between the August/Little Ben pit and Montana Gulch. Surface water would be routed to Montana Gulch.

Reclamation of all Zortman facilities is anticipated to occur within 3 years after the Goslin Flats heap leach pad has been detoxified and liner perforated. Final reclamation of all Landusky facilities is anticipated to occur within 3 years after the 87/91 leach pad has been detoxified and liner perforated.

The following sections summarize specific reclamation plans and actions for each of the major disturbance areas, and provide a description of prescribed modifications to the reclamation procedures.

2.11.2.1 <u>Reclamation Materials</u>

Reclamation materials would be required at both mines for construction and installation of reclamation caps and for use in construction of drains and diversions. The primary materials to be used in reclamation covers are cover soil, subsoils, and NAG materials such as gravels, limestone, and possibly waste rock. These materials would be used in construction of the reclamation covers to be placed on all disturbed facilities, unless otherwise noted.

This alternative requires the use of the reclamation covers incorporated in Alternative 3, as shown on Figure 2.11-3. Most of the information presented in Section 2.7.2.1 is applicable to this alternative and will be summarized, except where variances in sources and/or amounts exist between the two alternatives.

<u>Non-Acid Forming Material</u>

Non-acid forming material would be used primarily as a capillary break/drainage layer in water barrier reclamation covers, and to a lesser extent as rip-rap and drain material. The water barrier covers used in this alternative require a capillary break of 36 inches consisting of a suitable, NAG material. If additional subsoil is available (after incorporation into water balance covers) it would be preferred as a substitute for NAG in the water barrier covers.

Non-acid forming material to be used in the water barrier covers would come from the following sources, listed in order of preference:

<u>Zortman Mine</u>
Ruby Gulch Tailing
Goslin Flats Leach Pad Footprint
LS-2 Limestone Quarry
NAG Material Produced during Mining

Landusky Mine
Montana Gulch Waste Rock Dump
Montana Gulch Limestone Quarry
August #2 Waste Rock Dump
NAG Material Produced during Mining

Non-acid forming waste rock is being used as an interim cap on the Mill Gulch waste rock dump and in the Gold Bug waste rock repository, and as a cap on the 91 heap leach pad dike. Waste rock used in these facilities comes from existing stockpiles and that generated by the ongoing mine operation.

Under this alternative, the waste rock must meet the geochemical and lithologic criteria presented in the beginning of Section 2.11.2 and fully described in Alternative 3, Section 2.7.2.2 to be suitable for construction purposes and reclamation covers.

Limestone/Dolomite

Limestone for the Goslin Flats leach pad construction and use in reclamation would be mined from the LS-2 source northwest of the town of Zortman, within the existing mine permit boundary (see Figure 2.11-1). Limestone would not be mined from the LS-1 source, as proposed in Alternative 4, unless all other material sources are insufficient to meet reclamation requirements. Mining and haul road development to this source would occur as described in Alternative 3, Section 2.7.2.1.

Limestone and dolomite have been used in small amounts at the Landusky Mine. Because of their high carbonate content both of these rock types are useful to neutralize acidic conditions. Dolomite and limestone from outcrops within the mine permit area have recently been used to provide a 3-foot buffering liner across the floor of the 4,640-bench in the Gold Bug waste rock repository. Limestone and dolomite from the mine pits could not be used as a capillary break/drainage layer in the reclamation covers where GCL is used because of potential geochemical interaction with the GCL which could compromise the cover integrity. Supplemental limestone for reclamation would be mined from a source near Montana Gulch, within the existing mine permit boundary (see Figure 2.11-1). Limestone would not be mined from the King Creek quarry, as proposed in Alternative 4.

Cover Soil

Cover soil would be placed in at least a 12-inch thickness on all disturbances, either directly on top of NAG surfaces or as the top layer of reclamation covers. Soils used in reclamation of all facilities would be obtained from existing stockpiles, re-reclamation of disturbed areas, and development of the Goslin Flats leach pad and facilities. These sources and the amounts of material projected to be available for use in reclamation were fully described in Alternative 3, Section 2.7.2.1.

Subsoils, Gravels, and Colluvial Material

These materials would provide the 24-inch subsoil and/or 36-inch NAG layers required in the water balance and water barrier covers. These materials would be obtained from existing stockpiles, re-reclamation of disturbed areas, and development of the Goslin Flats leach pad and facilities. The sources and the amounts of material projected to be available for use in reclamation were fully described in Alternative 3, Section 2.7.2.1.

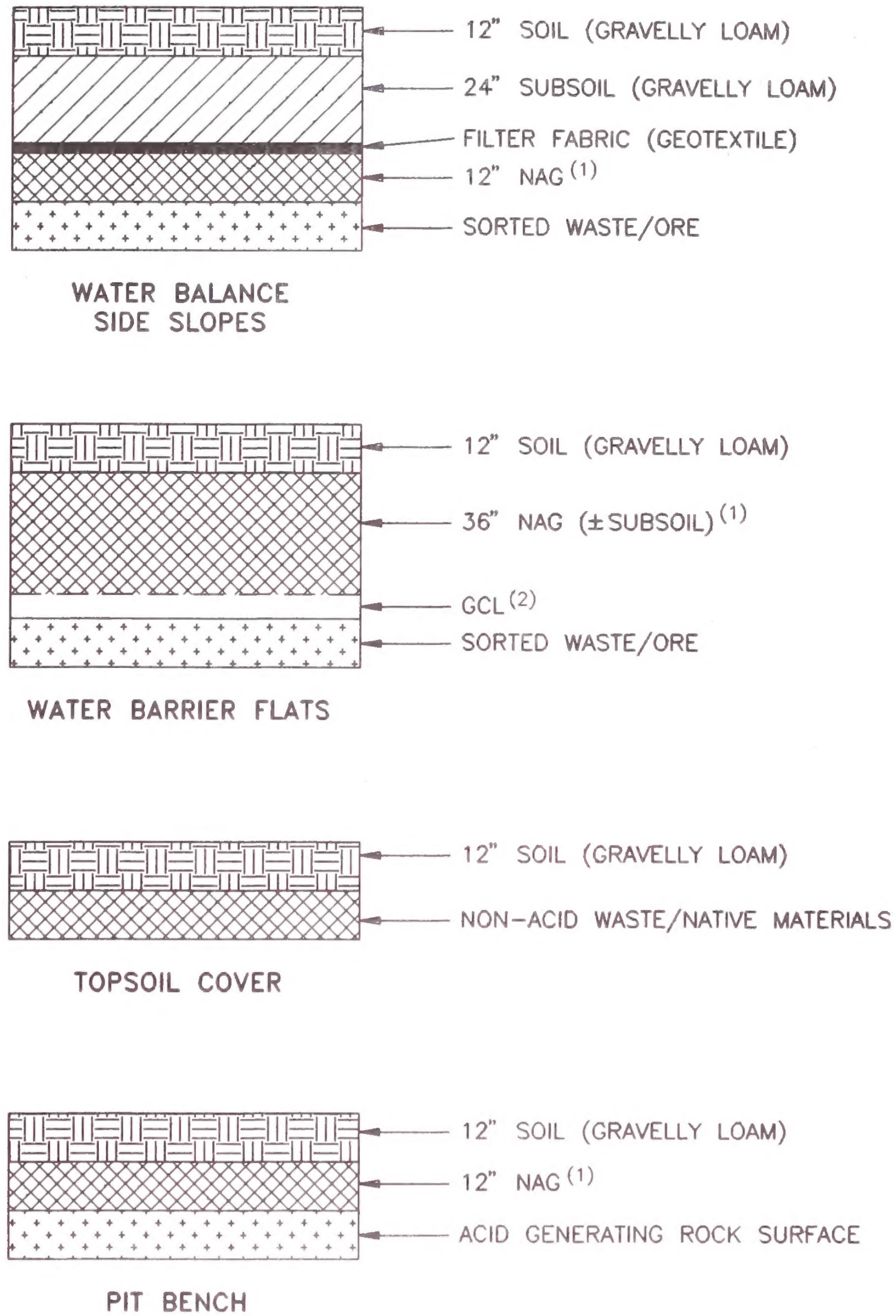
Geosynthetic Clay Liner

A GCL is essentially a combination of a thin bentonite clay layer sandwiched between two woven, synthetic layers called geotextiles. The bentonite provides a seal between the geotextiles. When the bentonite is exposed to moisture it swells, providing added protection against leaks or cracks. Pit bottoms, leach pad crowns, and possibly some other slopes may be at grades of less than 25 percent. These areas would require placement of GCL underneath the NAG layer.

2.11.2.2 Reclamation Testing and Covers

Section 2.7.2.2 described modified reclamation covers and presented the fundamental requirements for determining what type of cover will be used for each disturbance. Those procedures apply to this alternative. To summarize, water balance covers designed to limit infiltration by maximizing evaportranspiration would be placed on potentially acid generating facilities with slopes of 25 percent or greater. Water barrier covers would be used on potentially acid generating facilities with less than 25 percent slopes. These covers would provide additional assurance that ponded surface water does not infiltrate into materials which can create acid mine drainage. Pit benches would be covered with NAG material and cover soil, because they are assumed to be likely to create acidic conditions. Finally, 12 inches of topsoil would be placed on disturbances which are not likely to create acid mine drainage. The reclamation covers are shown on Figure 2.11-4.

The definition of NAG material is different, and more restrictive, than proposed in Alternative 4, Section 2.8.2.2. Certain rock types would be excluded from use in reclamation; those not excluded must demonstrate a



NOTES:

1. NAG – NON ACID GENERATING MATERIAL

2. GCL – GEOSYNTHETIC CLAY LINER.

ALTERNATIVES 3 AND 7
WATER BALANCE RECLAMATION COVERS
FOR ZORTMAN–LANDUSKY MINES

173E024A

FIG. 2.11–4

sufficiently high Paste pH, sufficiently low sulfur content, and appropriate neutralization potential. The criteria for material to be suitable for use in reclamation was presented in Section 2.11.2.

2.11.2.3 Mine Pit Reclamation

Mine pit reclamation would occur generally as described in Alternative 4, Section 2.8.2.3 with some modification concerning the source of pit backfill materials and sequencing of the reclamation. Pits within the complex which were mined out would be backfilled first, using waste rock from the active pits. Twenty-five foot thick lifts of waste rock would be placed and compacted using haul equipment.

Overall slope of the pit walls would be approximately 45 degrees (1H:1V) with 30-foot wide (flat) safety benches positioned every 60 vertical feet. Retreat reclamation would be used for pit benches. Instead of Reclamation Cover A, the cover on these areas would include 12 inches of NAG material below 12 inches of topsoil.

Surface water diversions would be installed to preclude runoff from contacting pit walls (that are likely to be acid forming) and which are too steep to be capped. The final pit floor would be capped using the water barrier cover described above. The final cover would be revegetated with native grasses and forbs. Revegetation of pit benches (where revegetation is possible) would include the use of trees to the extent possible to reduce visual impacts.

Additional waste material from other sources would be used to supplement the level of backfill at the Zortman Mine. This supplemental waste material or that generated by mining activities would be used to raise the pit floor to approximately 4,800 feet, an elevation necessary to freely drain the pit to Ruby Gulch. Figures 2.11-2 and 2.11-3 show the post reclamation pit configuration at the Zortman Mine.

The pit reclamation procedures for the Landusky Mine described in Alternative 3, Section 2.7.2.3 are generally those required under this alternative. The pit would be backfilled to a minimum elevation of approximately 4,740 feet, measured at the south end of the August pit, to create a surface which would freely drain into Montana Gulch. To accomodate the drainage, a channel would be developed between the August Pit across the bedrock divide into Montana Gulch. Material from this drainage cutout would be processed as ore or used as pit backfill. Other sources of backfill to reach the minimum elevation include the Montana Gulch waste rock dump, the August #2 dump, and material from partial removal of the 85/86 leach pad and dike.

2.11.2.4 Leach Pad Reclamation

Tasks associated with the reclamation of the heap leach facilities include heap detoxification, surface reclamation including slope reduction, reclamation cover placement, cover soiling and revegetation, and liner perforation. These steps have been described in detail previously. The following sections summarize the heap leach pad reclamation process from Alternative 4, Section 2.8.2.4 including modifications required under this alternative.

Heap Detoxification

The heap detoxification process for this alternative would be as described in Alternative 1, Section 2.5.2.4. In summary, the spent ore on the leach pad would be rinsed repeatedly with cyanide-free water to enhance degradation of cyanide compounds left in the heap. Heap detoxification is discontinued when the solutions returning from the heap maintain less than 0.22 mg/l cyanide (measured as WAD cyanide) for a six month period which includes a spring, high-flow surface runoff event. Heap solutions remaining after detoxification would be pumped to a containment pond for neutralization and later land application disposal.

Surface Reclamation

After the existing heap leach pads are detoxified, or concurrent with detoxification, surface grading begins to reduce pad slopes to an overall 3H:1V slope. Constructed benches must be placed every 100 feet of vertical spacing. Slope reduction is performed by track mounted bulldozers pushing ore heap material from the facility crest or top down over the lift slopes, using cut and fill material from each of the heap benches to obtain the desired slope. To achieve the desired 3H:1V slopes, off-loading of material would likely be required from some facilities. This would be done using loaders and haul trucks, and the off-loaded material would be dumped into the pits as backfill. Leach pad surfaces would be capped with water balance and water barrier covers, depending on the slope of the surface are, then revegetated.

Heap retaining dikes requiring reclamation would be reduced to a nominal slope of 2.5H:1V, or sufficient to allow placement and retention of the water balance cover. The dike faces would be capped with the water balance cover and revegetated to blend with existing undisturbed contact zones and reestablish vegetative communities.

Liner Perforation

The heap leach pad perforation requirements would generally be as described in Section 2.7.2.4. However, the liner perforation procedures would be modified by requiring that perforation be reversible in case leach pad drainage deteriorates to an unacceptable level after detoxification has been certified. Liner perforation techniques would be subject to approval by the agencies, but could include the use of horizontal drains or wells which could be sealed to stop drainage.

The 87/91 heap leach pad liner system would be perforated after pad detoxification and surface reclamation to eliminate moisture storage and any undesirable hydraulic conditions associated with the reclaimed facility. The liner would not be perforated until monitoring of the heap effluent indicates that water quality compliance has been met and risk of the formation of acid drainage is established to be minimal.

Existing Heap Leach Pads

Portions of the 85/86 heap leach pad and dike necessary to achieve a free draining surface would be removed and placed as backfill into the Zortman pit complex. Portions of this area would be incorporated into the expanded pit; the remainder would be capped with waste rock generated during mining activities. As described earlier, the waste rock would in turn be capped using the water balance reclamation cover, or water barrier cover on those slopes less than 25 percent.

Removal of the remaining portions of the 85/86 leach pad could be required at a later date. This action would be required if water quality objectives are not met in the receiving drainage.

The appropriate water balance or water barrier cover would be placed on top of those remaining leach pad disturbances which would not be capped by the waste rock repository. Generally, the leach pad areas not scheduled for cover by the waste rock repository include the 82 pad, and portions of the 79/80/81, and 84 pads (see Figure 2.11-2). Leach pad slopes would be reduced to 3H:1V, with benches every 100 vertical feet, to further limit surface water infiltration, stabilize cover soil, and enhance the potential for successful revegetation. Leach pad dikes would be reduced to a slope sufficient to allow placement and retention of the water balance reclamation cover.

Goslin Flats Leach Pad

The reclamation criterion for pad slopes under this alternative is 3H:1V, if topography allows, but no steeper than 2.5H:1V. Constructed benches must be placed every 100 vertical feet. Slope reduction would be performed by track mounted bulldozers pushing ore heap material from the facility crest or top down over the lift slopes, using cut and fill material from each of the heap benches to obtain the desired slope. Leach pad crests, top and slopes would be capped with the appropriate water balance or water barrier cover reclamation cover.

Other reclamation for heap retaining dikes and revegetation of leach pad surface would be as described in Alternative 6, Section 2.10.2.4.

2.11.2.5 Waste Rock Facilities Reclamation

Waste Rock Repository and Cover

The waste rock repository constructed at the Zortman mine site would be reclaimed concurrent with mine pit backfilling and as waste is placed over the existing leach pads. Waste material and reclamation material would be staged at the mine site to be available as reclamation proceeds. The final overall slope of the repository would be 3H:1V, and constructed benches would be placed every 100 vertical feet.

Existing Waste Rock Dumps

Three waste rock dumps (Alder Gulch, OK and Ruby Gulch) are currently located within the project boundaries of the Zortman Mine. The Alder dump and Ruby sulfide stockpile would be moved to the Goslin Flats leach pad. The remainder of the Ruby Gulch dump (after stockpile removal) would be leached, if testing demonstrates economically recoverable amounts of metals are present, or backfilled into the pit. The OK dump would be removed entirely as the expanded pit incorporates its location, and leached or used as backfill in the pit complex. Cover soil from this dump would be salvaged. Where these facilities are not covered by the new waste rock repository, their footprints would be tested for total sulfur content on 100-foot centers. Those areas with total sulfur content greater than 0.5 percent sulfur would be covered using the water balance cover (greater than or equal to 25 percent slope) or water barrier cover (less than 25 percent slope) shown in Figure 2.7-1. Areas with lower sulfur contents would be scarified, covered with 12 inches of soil and revegetated.

At the Landusky Mine, part of the Montana Gulch waste rock dump could be removed and used as backfill in the pit. The remaining footprint or unexcavated dump surface would be tested and re-reclaimed as needed with the water balance cover or water barrier cover. The interim cap placed on the Mill Gulch waste rock dump would remain as a permanent cover although it may need to be supplemented. A water barrier cover would be used on the Gold Bug waste rock repository. Reclaimed surfaces would be revegetated in accordance with Alternative 4, Section 2.8.2.8 unless otherwise stipulated in this alternative.

2.11.2.6 Support Facilities Reclamation

This section describes reclamation procedures for remaining mine facilities and disturbances.

Solution/Process Ponds Reclamation

Process and contingency ponds would be perforated, backfilled with compacted material and graded. Material excavated during the pond construction would be used for backfill, along with concrete materials from structure footings or pads. The graded pond areas would be cover-soiled with a minimumn soil cover of 12 inches and revegetated.

The carbon adsorption process for gold recovery generates little, if any, sludge. Sludges which might develop in processing ponds as the result of leach operations would be considered mine waste. The sludge would be sampled and a Toxicity Characteristics Leach Procedure (TCLP) performed to determine the mobility of any metals that may be present. If the TCLP analysis shows the sludge to be inert, it would be pumped to the leach pad for disposal prior to final cover of the heap. In the event mobile metals are present, the sludge would be fixed with cement, and the edge of the liner would be cut away from the anchor trench and folded over the cemented sludge prior to backfilling.

Process Plant Site Reclamation

Final reclamation would include the removal of all structures and equipment used in the mining and processing of ore through heap leach operations. Structures and equipment to be removed include:

- Existing processing plants, maintenance shop and support service structures
- Proposed crushing and processing facilities and equipment
- Proposed conveyer equipment
- Existing and proposed leach pad pumps and electrical structures
- Existing and proposed process spray and return lines
- Existing and proposed electrical power corridors (unless private, public, or regulatory agencies request continued use)
- Existing and proposed perimeter fencing of the property permit boundary
- Storage tanks and facilities
- Sediment control ponds and diversion ditches

All unoxidized bedrock exposed during construction activities and surfaces contaminated by spillage of non-oxide ore would be analyzed for total sulfur prior to reclamation activities. Materials shown to be potentially acid forming would be placed in the waste rock storage facility.

Reclamation of the process plant areas and service structures would include the dismantling and removal of all structures, concrete pads and footings. Concrete materials removed from the structures would be used for backfill materials for pond areas or disposed in an appropriate on-site waste disposal facility. All facilities would be dismantled and disposed as detailed below. The plant areas would be ripped by a track-mounted dozer, leveled and graded to facilitate surface drainage. Final graded areas would be cover-soiled with a minimum soil cover of 12 inches and revegetated to provide soil stability and re-establish vegetative communities.

It is estimated that 1,500 yd^3 of concrete would be removed and disposed. All steel structures would be salvaged or sold as scrap.

All solid waste generated during closure would be disposed in accordance with Montana laws and regulations of the DHES Waste Management Division. Inert waste (Class III, such as concrete, plastic, steel and wood) would be buried on-site in the waste rock repository or heap. Wastes not suitable for burial in a Class III facility, such as office waste and other Class II waste (household waste), would be transported to a landfill in the Lewistown area and disposed.

All footprints from these facilities and areas contaminated by spillage of non-oxide ore would be tested on 100-foot centers for total sulfur prior to reclamation activities. Surfaces found to contain greater than 0.5 percent sulfur would be covered with a water barrier cover, since surface slopes are expected to be much less than 25 percent, and revegetated. Other areas would be capped with 12 inches of cover soil and revegetated.

Soil Stockpile Reclamation

Cover soil stockpiles at the mines may be completely depleted by the time surface reclamation activities are completed. The footprints from the soil stockpiles would be tested on 100-foot centers. Those areas with total sulfur content greater than 0.5 percent sulfur would be covered with a water barrier or water balance cover, then revegetated. Areas with lower sulfur contents would be scarified, covered with 12 inches of soil and revegetated.

Access and Haul Roads

Haul and access roadways would be graded to re-establish natural drainage patterns. Roadways would be ripped to alleviate surface compaction and provide additional fill material for the drainage and grading of the roadway surface. Roadway berms and loose, unconsolidated material above and below the roadway cut would be pulled or dozed into the roadway using a backhoe or dozer. The amount of backfilling would be restricted by equipment limitations (e.g., slopes that can be traversed by dozers and by the backhoe reach). Where total recontouring is not possible, haul roads would be reclaimed by pulling at least four feet of sidecast material over the roadbed.

Haul roads would be sampled and analyzed every 100 feet to determine if acid forming materials are in contact with soil. Areas of the haul roads that have been constructed in acid-generating material would be covered with the appropriate water barrier or water balance reclamation cover. All final graded areas would be covered with a minimum of 12 inches of cover soil.

Cover soil would be sidecast and the fill toed next to the cover soil (see Figure 2.8-19 in the Company Proposed Action). When reclamation is accomplished, the fill material is replaced into the cut area and the cover soil is then spread over the fill. Cover soil thickness varies according to the cover soil available when the stripping was done for the roadway. However, it is anticipated that cover soil would be placed at a minimum thickness of 12 inches. Cover soil would not be hauled into areas for reclamation purposes with the exception of haul roads in the pit area. Haul roads left in the pits after completion of mining would be used for reclamation access to the pit. Final graded, cover soiled areas would be revegetated.

Three roadway sections connecting the Zortman, Landusky, and Hays townsite would remain after final reclamation. Sections of these roadway surfaces would be associated with operations haulage roadways. Such sections remaining after post-operations would be reduced from 70 feet wide to 25 feet wide. Therefore, the outer 45 feet of running surface would be ripped, contoured, cover-soiled, and revegetated.

The deviation from original topography from roadway reclamation varies significantly by site. Where haul roads, access roads and exploration roads are located in areas which require large cuts (10 feet or more); the roads generally would not be reclaimed to original contour. In contrast, roads located on gentle side hills or flats usually would be reclaimed to original contour.

The reclamation plan for access and haul roads includes:

1. Where possible (see explanation above), roadways would be graded to original contour.

2. Haul roads would be sampled and analyzed for total sulfur every 100 feet to determine if acid forming materials are in contact with soil;

3. Haul road segments identified as potentially acid forming (greater than 0.5 percent total sulfur), would be covered using the appropriate water balance or water barrier reclamation cover.

Conveyor Corridor Reclamation

Reclamation of the conveyor corridor disturbances would include dismantling and removal of all structures, concrete pads, and footings at the Zortman Mine. Concrete materials removed from the structures would be used for backfill materials or disposed in the Class III disposal facility. Surface construction disturbances associated with cut and fill operations to facilitate conveyor routing would be recontoured and blended with adjacent landforms. Surface disturbance areas would be cover-soiled and revegetated with native grasses, forbs, shrubs, and trees.

Limestone Quarries

The ultimate facilities development topography of the limestone quarries is proposed to consist of a 1H:1V quarry wall with 20-foot-wide benches every 60 vertical feet on the northeast side of the quarry. The quarry floor would be graded at a maximum 5 percent slope to facilitate drainage and prevent ponding of water. Rock

drains, rock lined swales, or other measures would be constructed as necessary to control erosion.

Cover soil would be placed to an approximate depth of 12 inches on the pit floor and all quarry wall benches. With the exception of the benches, the quarry wall would not receive cover soil. The floor of the quarry would be scarified as necessary to reduce compaction and increase bond with the cover soil. Areas covered with soil would be revegetated.

Haulage access roadways connecting the LS-2 quarry site with Zortman operations would be reduced to a running width of 25 feet along existing roadways. The outer 25 feet of running surface along the roadway would be ripped, contoured, cover soil with soil salvaged from the site and revegetated.

Vegetation is proposed to include nine tree and shrub types, and a grass seed mix of seven grasses that are native to the area. Steps in the revegetation process are described in Section 2.8.2.8.

If disturbed, the Montana Gulch limestone quarry would be reclaimed after mining has ceased. The salvaged materials (weathered limestone and cover soil) would be repositioned on the pit floor at a slope of 3H:1V or shallower. The post reclamation scarp heights on the limestone pits would vary from 0 to 30 feet. The disturbed areas would be revegetated with grasses, forb, trees, and shrubs as required in Section 2.8.2.8.

Clay Pits

Those areas in the Seaford clay pit already disturbed and reclaimed from previous operations would undergo additional reclamation, as would any new disturbances associated with this Alternative. A 3H:1V slope would be left after grading to allow runoff to proceed naturally downhill into the current drainage system. Cover soil would then be spread at an average of 18 inches, and a minimum cover of 12 inches, with vegetative seeding occurring during a seasonal period of higher precipitation. A seed blend of seven natural occurring area grass types would be used, as described in Section 2.8.2.8.

Those areas in the Williams clay pit already disturbed and reclaimed from previous operations would undergo additional reclamation, concurrent with reclamation for any new disturbances associated with this Alternative. A slope no steeper than 2.5H:1V would be left after grading to allow runoff to proceed naturally into the current drainage system to the southeast of the pit. Cover soil would then be spread at an average of 12 inches, and a minimum cover of 9 inches, with vegetative seeding occurring during a seasonal period of higher precipitation. A seed blend of seven natural occurring area grass types would be used, as described in Section 2.8.2.8.

Land Application

Following completion of all land application operations, the land application areas would be reclaimed. The pond liners would be removed and buried within the leach pads. Spray lines would be removed. Any surface excavations would be regraded to slopes no steeper than 3H:1V, which would then be cover-soiled and revegetated.

2.11.2.7 Reclamation Quality Control

ZMI, or a mine contractor overseen by ZMI personnel, would install the capillary break used in the water barrier cover. The capillary break thickness would be at least 3 feet over 95 percent of the area covered, with a minimum thickness of 2.5 feet at any location. The capillary break would consist of material which meets the rock type and geochemical characteristics for NAG material described in Section 2.11.2.1.

ZMI or a contractor would install the GCL. The installation would be monitored by a qualified independent third party contractor engineering firm experienced in the oversight of GCL installation.

The GCL is manufactured in large panels, bound into rolls for delivery to the site on flat bed tractor trailer trucks. The panels are unrolled at the installation area and placed on a prepared subgrade. Adjoining panels are overlapped and granular bentonite is placed between the overlapping panals. The GCL is hydrated with clean water; the bentonite is allowed to hydrate for a period of time; and then the GCL is overlain with a soil cover.

A properly installed GCL has a permeability of about 1×10^{-9} or greater. To maintain a quality construction, the GCL would be installed in accordance with the manufacturers specifications. Manufacturers Quality Assurance/Quality Control (QA/QC) guidelines for the proper installation of GCL liners typically include the following:

- Size and Type of equipment used to handle and install the GCL
- Foundation preparation and acceptance criteria
- Methods for GCL handling and deployment
- Panel layout and orientation
- Seaming

- Hydration
- Soil cover material type and placement method

The field engineer representing the third-party oversight contractor would be experienced in the installation of a GCL and would keep a daily written record of the installation, including documentation of quality control testing. The quality control testing would follow the manufacturers specifications and include the following testing:

- Bentonite Mass per unit area for the GCL
- Bentonite Free Swell
- Bentonite mass per unit length of seam

Monthly construction reports with testing results would be provided to the agencies.

2.11.2.8 Revegetation Procedures

Revegetation procedures for this alternative would not differ significantly from those presented in Alternative 4, Section 2.8.2.8. However, no trees would be used in revegetation except where specifically needed to mitigate visual impacts. Only grasses, forbs and shrubs would be used to enhance wildlife habitat. Another change is that Crested wheatgrass would not be used in the reclamation seed mix. Areas disturbed at the mines are and would be revegetated to stabilize soil and slopes, reestablish communities ecologically comparable to pre-mine conditions, and restore watershed, wildlife, recreational and aesthetic values that meet post-operation land use objectives. Vegetative cover must achieve 90 percent of that demonstrated in adjacent, natural communities of similar composition (i.e., shrubs, forbs and/or grasses) and location. Livetock grazing would be restricted in revegetated areas until the vegetation canopy is 90 percent or greater of the reference area and natural vegetation succession is established.

2.11.3 Monitoring Programs and Research Studies

The monitoring programs and research studies outlined in Alternative 1, Section 2.5.3 and Alternative 4, Section 2.8.3 would apply to this alternative except as where modified in the following sections. A reclamation monitoring program would be instituted to provide ongoing evaluation of surface reclamation viability.

2.11.3.1 Water Resources

The monitoring program for groundwater and surface water would continue as described in Alternative 4, Section 2.8.3.1. Some monitoring wells or surface water monitoring sites could be relocated as a result of actions taken to reduce slopes of heap leach facilities and waste rock dumps. The monitoring requirements for land application disposal areas outlined in Alternative 5, Section 2.9.3.1 would also apply. All monitoring required by other state or federal agencies are incorporated into this alternative by reference.

ZMI would be required to establish a monitoring program for operation and maintenance of land application disposal areas. This program, to be submitted to the agencies for review and approval prior to land application of spent solutions, would include at a minimum the following elements:

- Analysis of barren solution samples prior to land application and during, to determine optimum hydrogen peroxide rates and metals loading to soil.

- Installation of suction lysimeters at varying depths with the land application area.

- Collection of pore water samples (from lysimeters) and chemical analysis to include at least cyanide, arsenic, cadmium, copper, selenium, zinc, and lead.

- Daily or more frequent monitoring of land application operations by mine personnel to check for runoff from the area, or new groundwater seeps.

- Immediate sampling of all new seeps or discharges, or solutions found discharging from the area, and analysis for metals and cyanide.

Should any discharges from the area be detected, in the form of solution runoff or new seeps, all land application procedures would be stopped. The agencies must be informed immediately of any such occurrence and approve corrective measures prior to re-start of land application.

In addition to complying with the monitoring requirements discussed in Section 2.5.3 and Appendix A, ZMI would be required to add the following wells and sites to the water resources monitoring program.

<u>North of the Zortman Pit Complex</u>

- A deep bedrock well near the S-1 drainage and Pink Eye Pearl adit, northwest of the Ross Pit

- A deep bedrock well above Glory Hole Gulch, near the old Badger Mine portal
- An alluvial/bedrock monitoring well pair on the north side of the confluence of Glory Hole Gulch and Lodgepole Creek

South of the Zortman Pit Complex

- Maintain or replace a bedrock monitoring well pair at the base of the removed Alder Gulch waste rock dump

North/Northwest of the Landusky Pit Complex

- A deep bedrock well in the Narrows Fault Zone above King Creek
- A deep bedrock well in the Suprise Shear Zone above Swift Gulch
- A deep bedrock groundwater well in the Gold Bug Shear Zone near the northeast corner of the Queen Rose Pit above Swift Gulch
- An alluvial/bedrock monitoring well pair in the upper reaches of King Creek near surface water monitoring station L-5

Additional Surface Water Monitoring Stations

- Lodgepole Creek about 1/4 mile below confluence with Ross Gulch
- Tributary to Montana Gulch from 83 pad area
- Mainstream Montana Gulch where it enters BLM campground
- South Bighorn Creek at the Reservation Boundary
- Swift Gulch just above the confluence with South Bighorn Creek
- Swift Gulch above Spring L-20, below Gold Bug Shear Zone

Monitoring Frequency

The frequency of monitoring would be increased so that all groundwater monitoring wells and surface water monitoring stations are sampled quarterly (four times per year) and the full suite of water quality parameters (Table 2.5-18) analyzed each quarter. If a surface water monitoring station or groundwater monitoring well is found to be dry during several consecutive monitoring rounds, alternative flowing monitoring stations and/or water bearing monitoring wells should be installed in the immediate vicinity if at all possible.

2.11.3.2 Reclamation Surface Performance Study

Some expansion of the reclamation surface performance study would result from implementation of this alternative. ZMI would be required to monitor seepage from waste rock facilities on a frequency sufficient to develop long-term hydrographs for each site. The hydrographs would be used to assess and predict how and when seepage responds to high flow seasons or storm events. The hydrographs will also provide a tool for predicting opportunistic sampling events to evaluate changes in seepage quality.

2.11.3.3 Surface Reclamation Monitoring Programs

ZMI would implement a program to monitor long term viability of surface reclamation until such time as the agencies release the Mine Reclamation Bond. The program must evaluate the continued performance of such features as:

- Reclamation covers
- Revegetation success and permanence
- Erosion control measures

The reclaimed facilities would be monitored for excessive erosion including rilling and gullying. Excessive erosion would be that level which endangers the overall efficacy of the reclamation features and could hinder the achievement of reclamation goals or environmental compliance requirements. Soil loss could not exceed 2 tons per acre per year. ZMI would be required to notify the agencies of such concerns with the reclamation systems, and propose and implement approved corrective measures to alleviate concerns.

ZMI would be required to submit a surface reclamation monitoring plan to the agencies for review and approval.

2.11.3.4 Other Monitoring Programs

No changes are anticipated to the remainder of the monitoring programs from the descriptions provided in Alternative 4, Section 2.8.3.

2.11.4 Reasonably Foreseeable Future Actions

2.11.4.1 Powerline

An upgraded, 69 kV powerline as described in Alternative 4, Section 2.8.4.1 is a reasonably foreseeable development for this alternative.

2.11.4.2 Mine Activities

Proposals for future mine activities would be the same as described under Alternative 4, Section 2.8.4.2. The Pony Gulch ore deposit would likely be proposed for mining in the future. Due to concerns about impacts to air quality resulting from mining of Pony Gulch ore while Zortman mining and reclamation is ongoing, the Pony Gulch deposit would not be developed simultaneous with these activities at the Zortman mine site. Additional limestone resources are also likely to be proposed for mining. Passive water treatment measures would be proposed downgradient of mine facilities.

Since Alternative 7 is almost identical with respect to proposed mining at the Landusky Mine, foreseeable activities under this alternative are the same as previously described for Alternative 4, as described in Section 2.8.4.2. These developments include additional ore extraction from the existing pits, generation of a significant amount of waste rock as new ore is mined, construction and operation of a new leach pad in the Queen Rose/Suprise pit or at an alternate site, and the construction and operation of new or expanded water treatment facilities would be foreseeable.

2.11.4.3 Exploration Activities

It is anticipated that exploration proposals would be the same as described for Alternative 4 in Section 2.8.4.3. The additional 200,000 linear feet of road and trench construction, with 600 drillsites, over a 10-year period could be proposed.

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CHAPTER 3.0

AFFECTED ENVIRONMENT

INTRODUCTION

To evaluate the potential impacts resulting from the Proposed Action or the other Alternatives described in Chapter 2, it is necessary to understand the current environmental condition of the project study area. The study area for this project varies for each environmental resource, but it is generally the area encompassed by the Little Rocky Mountains. This Chapter describes the natural resources and the economic and social conditions found in the project study area.

3.1 GEOLOGY

The Zortman and Landusky mines are found within the Little Rocky Mountains of north-central Montana. Gold mining has taken place in the Little Rocky Mountains for over 100 years; as a result, an extensive database of information exists concerning the geology of the Little Rocky Mountains and the ore deposits contained therein. This section of the Affected Environment describes the regional geologic setting of the Little Rocky Mountains, the mineralogic associations and occurrences of the study area, and the structural forces which have played a major role in both the shape of the mountains and the locations of ore deposits. Subsections have been developed to address local geology in areas of particular importance such as Goslin Flats, where mine disturbance has not previously occurred, and geologic conditions which may control or influence other resources of importance such as groundwater.

3.1.1 Regional Setting

3.1.1.1 Topography

The Little Rocky Mountains are within the Northern Great Plains geographic region, which is distinguished by rolling prairies that are dissected or broken up by drainage systems. Plains mountains disrupt the landscape abruptly in this region. The plains mountains, including the Little Rocky Mountains, are called "Island Mountain Ranges" because they rise up out of the relatively flat plains like islands in an ocean. Other island mountain ranges in this region include the North and South Moccasin Mountains, the Bearpaw Mountains, the Sweet Grass Hills, and the Judith Mountains.

The Little Rocky Mountains rise in dramatic relief more than 2,500 feet above the surrounding plains. Old Scraggy Peak, located about 1.5 miles east of the Zortman Mine, is the highest point in the Little Rocky Mountains at approximately 5,700 feet above mean sea level (msl). In contrast, Goslin Flats south of the Town of Zortman is at an elevation of approximately 3,800 feet msl and the plains further south and east are significantly lower. Ft. Peck Lake, east of the Little Rocky Mountains, is about 2,300 feet msl. The topography within the Little Rocky Mountains is rugged, marked by high outcrops of erosion resistant rocks and steep, V-shaped valleys with little accumulation of soil or alluvial materials.

The plains surrounding the Little Rocky Mountains are relatively flat but they have been dissected by surface water runoff channels, resulting in steep cliffs and badlands-type topography in some areas. Southwest and south of the Little Rocky Mountains, the topography is strongly influenced by the drainage of the Missouri River. Intermittent streams and coulees coalesce to form tributaries of the Missouri River, and the topography becomes more broken as the drainages easily incise through the relatively soft sedimentary rocks which make up most of this region.

3.1.1.2 Geologic Setting

The Little Rocky Mountains are found in a region exhibiting geologic extremes in rock types, history of rock formation and emplacement, and age of materials. The regional geology ranges from upland prairie which has been glaciated as recently as 10,000 years ago, to the nearly 3 billion year old rocks exposed in mountainous areas (BLM 1992b).

The oldest rocks in the region are Precambrian Era (those >650 million years old) metamorphic gneisses and schists. Metamorphic rocks are those which have been altered in texture or composition due to temperature, pressure, and/or chemical processes. These very old rocks outcrop only in some of the mountain ranges, including the Little Rocky Mountains, where magma upwelling from below the earth's surface has pushed older rocks up through younger strata.

Thick sequences of Paleozoic Era (570 to 240 million years ago) sedimentary rocks are found in the mountain ranges and on the plains. Sedimentary rocks are those which have formed by the accumulation of sediments or minerals precipitated from water. These rocks are predominantly limestones and dolomites which typically formed in marine environments, but sandstones and shales also occur. These are the rock types which usually do not contain much gold or precious metals, but they are still important in mining because they can be used in construction or as reclamation materials. Limestones, dolomites, and other "calcareous" rocks (those containing significant amounts of calcium carbonate) are very useful because they can neutralize or buffer water which has been acidified by mine operations. These rocks are very resistant to erosion and form some of the spectacular cliffs in the mountain ranges; they also contain some important cave formations, such as Azure Cave on the south side of the Little Rocky Mountains.

Mesozoic Era (240 to 66 million years ago) rocks are also sedimentary in this region. Sedimentary rocks from the Jurassic period of the Mesozoic are typically calcareous sandstones and shales. Gypsum and coal have been mined from Jurassic sediments in the region. Cretaceous period rocks are sedimentary, with the different rock formations representing episodes of advance and retreat of a large inland sea which covered much of North America at that time. These sediments include sandstones, shales, and limestones. Coal and bentonite have been mined from various Cretaceous formations. Thick carbonaceous shales from the Cretaceous have also provided a source of oil and gas development in the region.

The geology and topography of the region has been greatly influenced by two activities during the Cenozoic Era (66 million years ago to the present). Extensive igneous activity occurred during the early Cenozoic (known as the "Tertiary" period), resulting in the formation of the Island Mountain Ranges described earlier. This igneous activity in Montana appears to follow the structural controls of a regional feature known as the Great Falls Tectonic Zone. Described by O'Neill and Lopez (1985), the Great Falls Tectonic Zone is a belt of northeast-trending geologic features that can be traced from the Idaho Batholith in north-central Idaho and western Montana, across the overthrust belt structures of southwestern Montana, through central Montana and into southwestern-most Saskatchewan, Canada. Geologists believe the Great Falls Tectonic Zone controlled the intrusion patterns and orientation of Late Cretaceous to early Tertiary igneous intrusions and dike swarms, including those of the Little Rocky Mountains and other area mountain systems.

More recently, during the "Quaternary" period of the Cenozoic, massive glaciers advanced and retreated over much of the region leaving glacial deposits and debris in most of the area north of the Missouri River. Erosive forces have continued to alter the region's landscape, removing weathered bedrock from mountainous areas and depositing it as unconsolidated deposits in valleys and plains.

3.1.2 Geology of the Little Rocky Mountains

The Little Rocky Mountains are an elliptical dome 10 miles long which was formed by the emplacement of an igneous intrusion during the Tertiary period, approximately 65 million years ago. They are known as "intrusive" igneous rocks because they solidified below the surface, whereas "extrusive" or volcanic igneous rocks were extruded onto the surface in a liquid state and solidified during cooling. Other rocks exposed in the area are sedimentary or metamorphic, as described in the previous section. Surface materials include soil derived by the breakdown of bedrock in the area; alluvium, which is generally the material deposited from running water and other erosive forces; and, in the northern part of the Little Rocky Mountains, debris from glacial activity. The southern portion of the Little Rocky Mountains appears to have escaped glaciation, as evidenced by the sharp topography (V-shaped valleys) and absence of glacial deposits. Sub-surface bedrock underlying these rocks range in age from Precambrian to those of Tertiary age. Figure 3.1-1 displays the general surficial geology of the Little Rocky Mountains.

The domed shape of the Little Rocky Mountains is well illustrated in Figure 3.1-2. The youngest bedrock, the Tertiary-age igneous rock in the middle of the figure, has pushed up older, once horizontal rocks of varying age and origin. The oldest rocks exposed are the Precambrian metamorphics including schists, gneisses, and quartzites. The Precambrian metamorphics were originally sedimentary or volcanic rocks rich in the minerals quartz and feldspar. Alteration to the presently seen metamorphic mineral assemblage presumably occurred during Precambrian time, because the younger overlying sedimentary rocks do not appear to have suffered alteration.

The rock types shown in Figure 3.1-2 are younger with increasing distance from the Precambrian rocks near the center of the dome. Most of the Paleozoic sedimentary rocks in this area were created in a marine environment.

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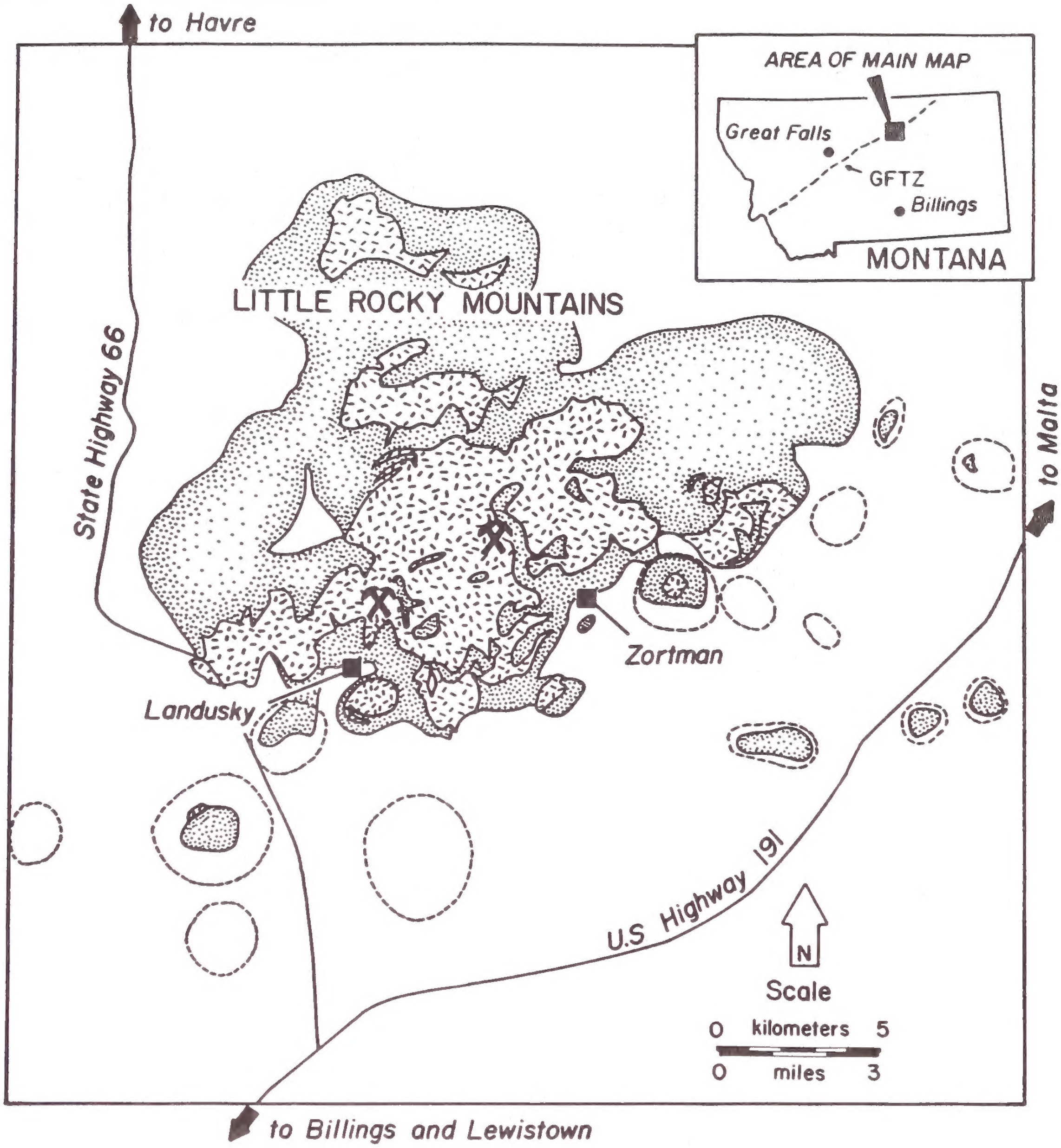


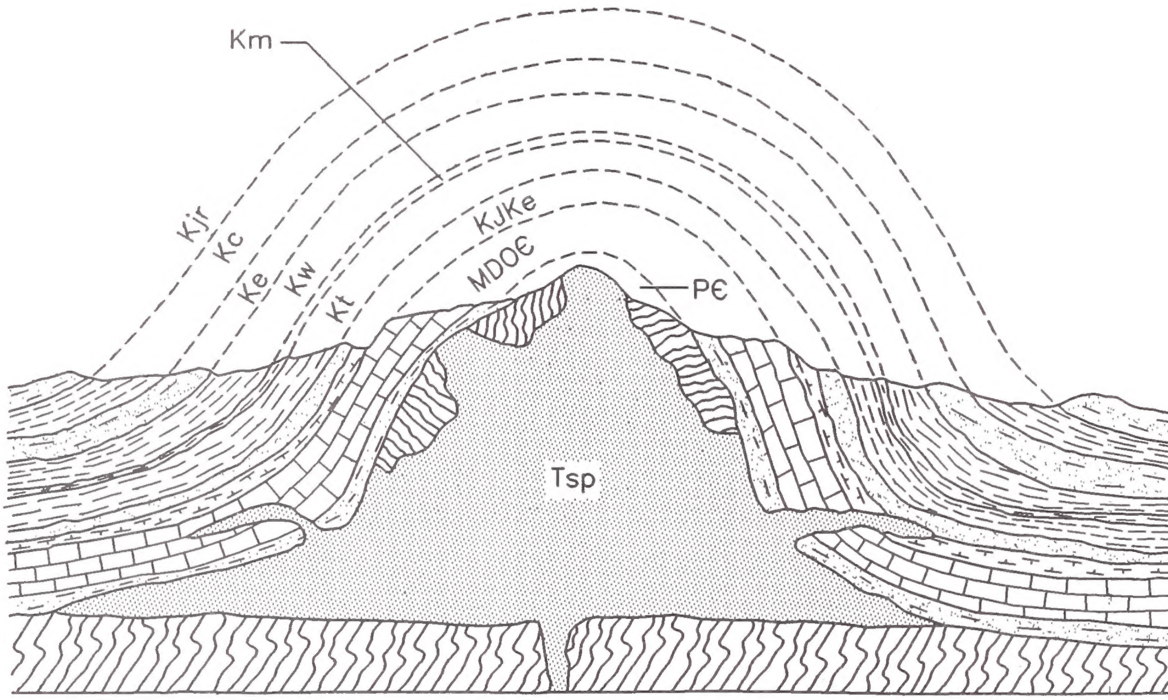
LEGEND

TERTIARY PORPHYRIES	DOMES
MESOZOIC (AND LATER) ROCKS AND SEDIMENTS (EXCLUDES TERTIARY PORPHYRIES)	MINE AREAS
PRE-MESOZOIC ROCKS	GFTZ GREAT FALLS TECTONIC ZONE

SOURCE: FROM RUSSELL 1991

GENERAL SURFICIAL GEOLOGY OF THE LITTLE ROCKY MOUNTAINS

FIG. 3.1-1



LEGEND

SYMBOL	TYPE ROCK	FORMATION AND LITHOLOGY	ERA	RELATIVE AGE (YOUNGEST TO OLDEST)
Tsp	IGNEOUS	INTRUSIVE SYENITE PORPHYRY	C	TERTIARY
Kjr	SEDIMENTARY	JUDITH RIVER FORMATION SANDSTONES AND SHALES	M	CRETACEOUS
Kc	SEDIMENTARY	CLAGGETT FORMATION SHALES	M	CRETACEOUS
Ke	SEDIMENTARY	EAGLE FORMATION SANDSTONES AND SHALES	M	CRETACEOUS
Kw	SEDIMENTARY	WARM CREEK FORMATION SHALES	M	CRETACEOUS
Km	SEDIMENTARY	MOWRY FORMATION SHALES	M	CRETACEOUS
Kt	SEDIMENTARY	THERMOPOLIS FORMATION SHALES	M	CRETACEOUS
KJKe	SEDIMENTARY	KOOTENAI FORMATION SANDSTONES AND JURASSIC-AGE SANDSTONES AND LIMESTONES	M	CRETACEOUS AND JURASSIC
MDOЄ	SEDIMENTARY	VARIOUS LIMESTONES OF THE MADISON GROUP, ALSO SANDSTONES SUCH AS THE FLATHEAD FORMATION	P	MISSISSIPPIAN
PЄ	METAMORPHIC	GNEISS, SCHIST, AMPHIBOLITE	PЄ	PRECAMBRIAN

SOURCE:

FROM RESPONSE TO COMMENTS REVIEW #3, 1993.

C = CENOZOIC
M = MESOZOIC
P = PALEOZOIC
PЄ = PRECAMBRIAN

GENERALIZED CROSS-SECTION THROUGH THE LITTLE ROCKY MOUNTAINS

ZORT31-2

FIG. 3.1-2

These sedimentary rocks are more resistant to erosion and may form prominent buttes, ridges, and cliffs. The deepest (and oldest) of the sedimentary formations is the Flathead sandstone. It is overlain by approximately 3,000 feet of limestones and dolomites, with lesser amounts of shale, sandstone, and conglomerate. The top sequence of Paleozoic rocks consists of Madison Group limestones, which are found in much of Montana. Most Paleozoic rocks in this area, particularly the Mission Canyon and Lodgepole limestones of the Madison Group, are very resistant to erosion and form the dramatic cliffs seen in some high rock outcrops.

The Mesozoic rocks in the area consist primarily of shales, with lesser amounts of sandstones, conglomerates, and limestones. In general, the Mesozoic rocks represent terrestrial and near-marine environments, when sediments from earlier ages were eroded and redeposited in valley floors, river and stream beds, and outwash plains. These sediments are found as bedrock at or near the surface in the areas around the Little Rocky Mountains. A fairly complete stratigraphic section, from Pre-Cambrian metamorphic basement rocks to Cretaceous (Bearpaw Shale), is exposed along the flanks of the mountains.

Younger rocks of the current Cenozoic era are igneous intrusives. The igneous rocks in this area are known as syenite porphyries. Emplacement of the Cenozoic intrusive rocks resulted in the formation of the Little Rocky Mountains, as described at the beginning of this section. In addition, intrusion of the igneous rocks mobilized and deposited elements such as gold in sufficient concentrations as to make mining often economically viable.

3.1.3 Mineralogy and Mining History

The reason gold and other precious metals have been found in the Little Rocky Mountains is directly related to the solidification history of the igneous porphyry rocks. After upwelling and emplacement of the igneous magmas, a hydrothermal system dominated by low pH, low salinity waters heated by the igneous magma developed (Russell 1991b). This hot, acidic water caused widespread alteration in rocks of the Zortman/Landusky Mining District. Hydrothermal flow of the heated waters was channeled along the existing structural trends of the intrusive rocks. Gold, silver, and associated minerals such as pyrite were dissolved in the hot water because of the low pH. Changes in pressure, fluid chemistry, or reductions in temperature could cause the pH of the water to increase, resulting in precipitation of gold and minerals. The minerals were typically distributed within the structural channels, often in dikes or veins of quartz, or along fracture zones of crushed and broken rock called breccias. Metal sulfide minerals and gold were also disseminated throughout the rocks. Ironically, some of the current environmental problems at the Zortman and Landusky mines result from what is essentially a reversal of this process. As the minerals in waste rock and ore are exposed to air and water during mining, the sulfides react to form sulfuric acid and lower the pH of the water. This acidification process partially dissolves minerals back into solution. A more extensive explanation of this condition, called Acid Rock Drainage, is found in Section 3.2.2.

Vein lode deposits of gold were first discovered in the Little Rocky Mountains in 1892. The vein deposits are typically the most heavily enriched in gold or other precious metals; hence, they are the most valuable deposits. They were also relatively easy for the lone prospector or small operation to mine, because mining only required that the "vein" be followed.

Natural erosional forces also created new, localized areas of concentrated gold. Rain, snow, and seasonal weathering of the mountains and mineralized zones break up rock in the higher elevations and carry it down into stream channels, valleys and basins. Deposits of eroded material from mineralized zones are called placers. Placer deposits were often the first and best indicators to the old prospectors of the last century that ore zones could be found in the higher areas of mountain regions. This is the case for the Little Rocky Mountains. The first placer deposits were developed in Alder Gulch in 1884, and the first lode claims in this area were patented in 1892.

Some very rich "bonanza-type" gold ore has been produced in the Little Rocky Mountains from the vein deposits described above; however, most production has come from relatively low grade ore (typically ranging from 0.022 to 0.028 ounces per ton, although even lower grades have been mined at Landusky). The mineral deposits occur in the altered syenite porphyries, and are associated with high-angle faults or fractures, the channels along which mineralized hydrothermal waters had access. At the Zortman Mine, gold mineralization has been concentrated at the intersections of north and northwest-trending mineralized fractures, and occurs as finely disseminated particles. To date, the most important ore bodies have been within the porphyry-hosted "breccia" dikes, the rock-type resulting from crushing and grinding along a fault or fracture. Sulfide mineralization in the OK Breccia, a mineralized breccia 15 to 100 feet wide emplaced along a northwest-trending fracture, extends from the surface to an average depth of 500 feet. In the Landusky area, economically viable gold deposits are found where the number and/or extent

of fractures is greatest. These systems on the Landusky side parallel the inferred southwest to northeast trend of the Great Falls Tectonic Zone.

At both mines, the oxidized portion of the ore bodies has been of most interest to the mining companies, because the gold and silver concentrate in oxidized zones. Oxidation of the ore generally has occurred nearest the surface, and along fractures which have transported rain, surface water, and shallow groundwater deeper in the ore zones. Gold and silver are easy to separate from the host rock in oxidized ores using cyanide heap leach processes. When occurring along natural fractures, these metals require only blasting and leaching to recover. The gold and silver in unoxidized zones are more tightly bound in the geochemical matrix of the rock, thereby making it more difficult to release the minerals from the ore using heap leaching processes. The precious metals-bearing minerals are spatially associated with sulfide mineralization. Iron sulfides are the most abundant species, including minerals such as pyrite, marcasite, arsenopyrite, and others.

3.1.4 Structural Geology

As previously discussed, the outline of the Little Rocky Mountains is elongated to the northeast, along the projected path of the Great Falls Tectonic Zone. The numerous domes and intrusives coalesce in the interior of the Little Rocky Mountains to form a central, larger dome complex.

3.1.4.1 Little Rocky Mountains

The Little Rocky Mountains were originally interpreted to be laccoliths, a term used to describe igneous intrusions with flat bases and domed roofs which arch the overlying sediments according to the shape of the igneous dome. Recent mapping indicates that the mountains consist of a central core of igneous rocks which is bounded by domed sedimentary units and flanking igneous domes along fault zones. Russell (1991a) cites field indications that the intrusions were not emplaced concordantly, or parallel to the sedimentary formations which were already in place. In addition, he notes that active mining and exploration drilling in the Zortman and Landusky pits has failed to reach a floor or bottom to the intrusion. This cumulative evidence suggests the porphyries were not intruded as laccoliths but as stocks, a type of igneous intrusion which is relatively small in size and which cuts across formation boundaries. The structure of the intrusion found in Figures 3.1-2 and 3.1-3 displays features of a laccolith (mushroom shaped with a relatively flat floor) and a stock (the intrusion is small and cuts across some lithologic boundaries).

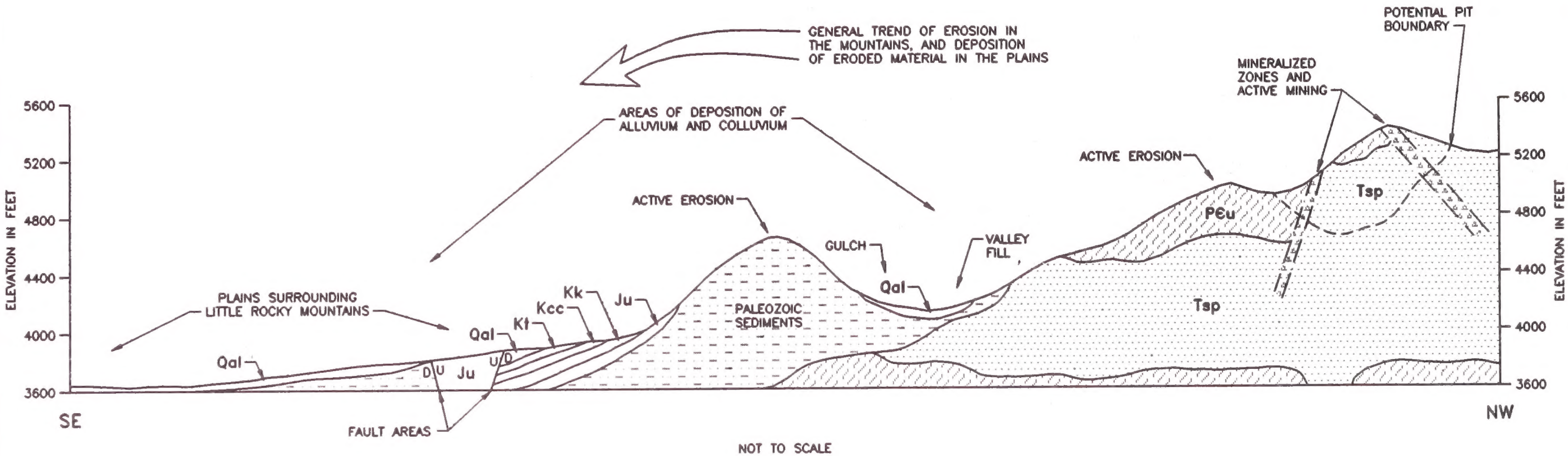
The major controls on the geologic structure of the area are steeply-dipping, north-northwest trending fractures. Most faults *between* the intrusions and surrounding sedimentary rocks are steeply dipping (i.e., more vertical than horizontal) with a relatively large component of up or down movement. Most faults *within* intrusions are described as shears, suggesting more lateral than vertical movement along the fractures. As noted previously, these fault structures had a major influence on localization of mineral deposits. Faults, joints, and fractures can also play an important role for groundwater transport in the Little Rocky Mountains, particularly in controlling the direction of flow.

Figure 3.1-4 is a simplified geologic sketch with important fractures and structural features of the central portion of the Little Rocky Mountains, where the Zortman and Landusky mines are located. From this illustration it is easy to see that most mineralized fractures (those containing precious metals) trend north-northwest in the vicinity of the Zortman Mine, and north-northeast in the vicinity of the Landusky Mine. Major faults tend to have the same alignment. This figure also illustrates how the major mine workings are situated along the fracture zones.

3.1.4.2 Goslin Flats

The Zortman Mine expansion's proposed heap leach facility would be located in the Goslin Flats, an area approximately one mile south of the town of Zortman, on the eastern flank of Saddle Butte. Goslin Flats has received erosional debris from the mountains to the north and west. The predominant lithologies which provide alluvial material to the Flats are shales, siltstones, limestones, and sandstones, all sedimentary rocks which have been folded and faulted by earth movement, and therefore no longer lie flat on the surface as originally deposited. These faults occurred during emplacement of the igneous intrusions, including the Little Rocky Mountains, during the late Cretaceous possibly 70 million years ago. This tectonic activity ceased during the early Tertiary, and no further activity has occurred which would cause activation of these faults or additional movement.

ZMI has drilled several borings and excavated a number of test pits in the Goslin Flats area to determine the depth of alluvium and character of the underlying bedrock. A relatively thin layer of topsoil typically covers one to two feet of colluvium, the material deposited as a result of downslope movement from the adjacent high areas. The soil and colluvium are described in Section 3.3.2. Underlying alluvial deposits



NOT TO SCALE

L E G E N D

Qal	QUATERNARY UNCONSOLIDATED DEPOSITS
	TERTIARY BRECCIA
Tsp	TERTIARY SYENITE PORPHYRY
Kt	THERMOPOLIS SHALE
Kcc	CUT CREEK SANDSTONE
Kk	KOOTENAI SANDSTONE
Ju	JURASSIC SEDIMENTS, UNDIFFERENTIATED
	PALEOZOIC SEDIMENTS, INCLUDING LIMESTONES OF THE MADISON GROUP
PЄu	PRECAMBRIAN GNEISS SCHIST, QUARTZITE

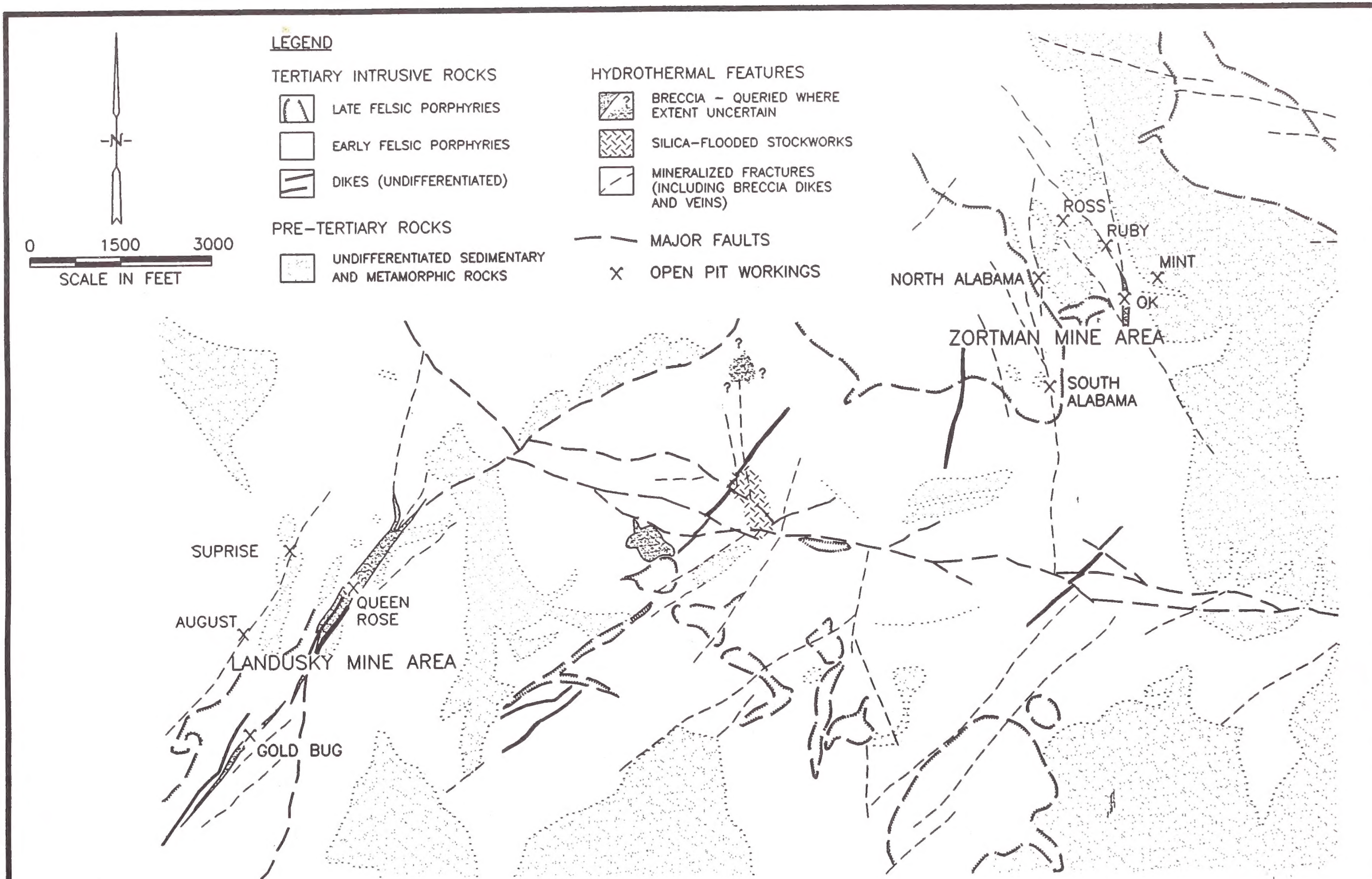
NOTE: THIS ILLUSTRATION PRESENTS A GENERALIZED VIEW OF TYPICAL TOPOGRAPHY AND SUBSURFACE GEOLOGY IN THE VICINITY OF THE ZORTMAN AND LANDUSKY MINES. THE HGHEST MOUNTAINS ARE FOUND WHERE IGNEOUS INTRUSIONS HAVE UPLIFTED OVERLYING AND SURROUNDING SEDIMENTS AND METAMORPHIC ROCKS. ACTIVE MINING OCCURS AT THE FRACTURES AND CONTACT AREAS WITH MINERALIZED ZONES. THESE ARE ALSO THE ROCKS THAT ARE MOST LIKELY TO CAUSE ACIDIC DRAINAGE WHEN DISTURBED BY MINING ACTIVITIES. SURROUNDING SEDIMENTARY ROCKS, SUCH AS THE PALEOZOIC LIMESTONES OF THE MADISON GROUP, TEND TO HAVE HIGHER CONCENTRATIONS OF CALCIUM CARBONATE WHICH REDUCE ACIDIC RUNOFF FROM THE IGNEOUS OR METAMORPHIC ROCKS.

THIS FIGURE ALSO SHOWS HOW ROCKS FROM THE HIGH COUNTRY ARE REDISTRIBUTED BY EROSIVE ACTION TO LOWER AREAS. WIND, RAIN, AND OTHER PHYSICAL AND CHEMICAL FORCES BREAK DOWN THE ROCKS IN THE MOUNTAINOUS AREAS. THESE ARE CARRIED BY SURFACE WATER FLOW OR GRAVITY TO LOWER AREAS AS ALLUVIUM OR COLLUVIUM. THEREFORE, THE STREAM VALLEYS IN THE LITTLE ROCKY MOUNTAINS AND SURROUNDING PLAINS HAVE ACCUMULATIONS OF SOIL, SAND, GRAVEL, AND OTHER UNCONSOLIDATED MATERIALS WHICH MAY BE USEFUL IN THE CONSTRUCTION AND RECLAMATION OF MINE FACILITIES.

SIMPLIFIED GEOLOGIC CROSS-SECTION

ZORT3131

FIG. 3.1-3



FROM: GEOLOGY OF THE CENTRAL PORTION OF THE LITTLE ROCKY MOUNTAINS, RUSSELL, 1991.

GEOLOGICAL SKETCH MAP
CENTRAL LITTLE ROCKY MOUNTAINS

FIG. 3.1-4

ZORT-GSM

range in thickness from approximately a few feet to 35 feet or more, with deposits greater than 48 feet found near Ruby Creek. The alluvium typically consists of variable amounts of gravel, sand, silt and clay. Older alluvium, overlying the bedrock formations, usually consists of gravels and cobbles with thin lenses of silty clay and stratified sand.

Below the alluvial material is the Thermopolis Formation shale, underlain by the Kootenai Formation sandstone. The shale is described in Appendix 1 of the Plan of Operations (Golder Associates 1993) as typically calcareous with occasional siltstone and limestone beds. The calcareous nature of the upper portions of the Thermopolis shale is a consideration in evaluating the overall suitability of the Goslin Flats for a heap leach system since a calcareous chemistry would help to buffer leachate (i.e., reduce acidity) which discharges from the facility. Under the Thermopolis shales are various shallow dipping, siltstone, sandstone, and shale units of the Kootenai Formation.

Another feature of the shale is its effective friction angle, or the capacity for overlying lithologies to resist slipping on the shale. This engineering factor is important to the leach pad design because significant pressure will be placed on the shale from the weight of loading approximately 200 vertical feet of ore. Increasing the potential for slippage is the fact that shale is very fine grained, composed largely of clay minerals that align in horizontal layers. In addition, groundwater perched on top of the shale would probably increase the potential for slippage at the shale/alluvium contact. The engineering viability of this location is discussed in more detail in Section 4.1.6. Cross sectional maps of the Goslin Flats subsurface are also available in Appendix 1 of the Plan of Operations (Golder Associates 1993).

3.1.5 Surficial Geology

The rocks found at the surface in the Little Rocky Mountains are generally illustrated in Figure 3.1-1. These are primarily crystalline igneous or metamorphic rocks in the core of the complex, with tilted sedimentary deposits flanking the core. These rocks were described earlier. Other surface materials include unconsolidated alluvium, glacial debris, and soil which were deposited in late Tertiary or even more recently in Quaternary time, within approximately the last 10,000 years. Alluvial deposits resulting from erosional activity, generally consisting of gravel, sand, and silt, occur in two areas:

- Slightly inclined surfaces on bedrock that slope away in all directions from the base of the Little Rocky Mountains
- On recent flood plains of several streams which flow only intermittently

These deposits contain fragments of materials derived from outcropping bedrock units, and consist of various sized fragments of the igneous porphyry, metamorphic quartzite and schist, and sedimentary limestone, dolomite, and sandstone. There are large accumulations of rock debris at the bottoms of hills and ridges.

Figure 3.1-3 is a simplified geologic cross section which illustrates how natural erosive forces have typically shaped the terrain and controlled the surficial geology within the Little Rocky Mountains, near the Zortman and Landusky Mines. To understand what a geologic cross section is, consider as an example how a layer cake looks before it has been sliced. You can see the surface of the cake, but you cannot know what the inside looks like. When the cake is cut in half, and one of the halves removed, all the layers are exposed from the side. This is how a geologic cross section displays the topography of the earth's surface and the rock types, faults, folds and other features of interest in the area being studied.

The igneous intrusion responsible for the mountain building in the Little Rocky Mountains is shown at the far right side of the figure. Mining would occur at mineralized zones within or on the boundaries of this intrusion. The far left-hand side of the cross section displays a lower area, typical of the plains or pediments on the edge of the Little Rocky Mountains, where erosional debris from the sediments uplifted in the central complex (right side of the cross section) have been deposited. The unconsolidated deposits of the plains and other topographically low areas can be important to the Zortman and Landusky mining activities. Rock debris may be useful as rip-rap, coarse alluvium can be used as aggregate and in road base, and sand deposits could be used as underpad for liners and in the leach facility for drainage. Those sediments which are calcareous and will not generate acid are of use as reclamation materials because the calcium carbonate can buffer or reduce acidity.

3.1.6 Geologic Hazards

The Little Rocky Mountains are situated in an area of low earthquake hazard. Based on the probabilistic earthquake acceleration and velocity map for the United States (Algermisson et al. 1990), the Little Rocky Mountains are located within the lowest risk area designated. There are no known unstable areas, although landslides/rockslides are always a potential hazard where steep slopes and ridges are common, such as in the interior of the Little Rocky Mountains. Although faults are present as described in the previous

section, none are believed to be currently active, or to have been active in recent times.

Another localized hazard at the Landusky and Zortman Mines is related to previous mining activities. Underground (stope) mining was prevalent in the Little Rocky Mountains until ZMI applied open-pit mine and large scale ore processing technology to the area. As a result, a relatively large network of underground shafts and tunnels exists; some of these underlie roads or other areas and facilities used for current mining activities. The hazard presented by the underground mine workings is that there may be insufficient ground support underneath the active mining operations, resulting in surface slumps similar to those commonly associated with sinkhole formations. ZMI has instituted a program to identify areas of hazard to reduce potential injuries or property damage.

Ore and waste rock containing sulfide minerals have been mined previously, and the proposed mine would move more sulfide-bearing rocks. A geologic hazard related to this mining activity is Acid Rock Drainage, or ARD. ARD can be produced when ore or waste rock containing sulfide minerals comes in contact with air and water. Section 3.2.2 of this document includes an expanded discussion of water resources and geochemical conditions leading to acid rock drainage.

3.1.7 Geologic Resources

The primary geologic resources of economic importance in or near the Little Rocky Mountains are the gold and silver, and other lesser metals, mined at the Zortman and Landusky Mines. Other geologic resources in the area include oil and gas, clay, rock aggregate, and limestone.

3.1.7.1 Precious Metals

Section 3.1.3 provided a summary of the mining history in the Little Rocky Mountains and the mineralogic associations of precious metals, particularly gold and silver, within the igneous intrusions and hydrothermal fracture zones. As outlined in Section 2.5, approximately 20 million tons of gold and silver bearing ore have been removed from the Zortman Mine by ZMI during the years 1979 to 1994, and about 100 million tons of ore have been removed from the Landusky Mine by ZMI during the same years. Table 3.1-1 provides a breakdown of the estimated gold and silver production from the Little Rocky Mountains Mining District from the years 1860 to 1994.

Additional resources of gold and silver exist within the Little Rocky Mountains, including that found in ore which ZMI has proposed to mine as part of the Proposed Action described in Section 2.8.1. Section 2.8.4 identified other, reasonably foreseeable deposits, including one in Pony Gulch which has been estimated to contain about 2 million tons of ore. Lower grade ores which are not economically feasible to mine using current technology are also present in the Little Rocky Mountains.

3.1.7.2 Clay Minerals

Certain clays minerals, such as bentonite, have commercial value in a wide variety of products. Other clays which may not have commercial applications comparable to bentonite can be used in a variety of applications, including the mining construction, operations, and reclamation activities conducted at the Zortman and Landusky Mines. The following section provides a description of these materials.

Bentonite

Bentonite is composed of clay minerals which have the peculiar capacity to absorb water and swell in volume. It is generally formed by the alteration of volcanic ash which has been deposited in a marine environment. The formation in this area which has commercial deposits of bentonite is the Bearpaw Shale of the Late Cretaceous Montana Group. The absorption and swelling properties of bentonite deposits determine the commercial use of the product. Bentonite has been used in the production of brick, drilling fluids, fertilizer, pottery, and a number of applications. Until the late 1970s the general use of bentonite in the region was pit run bentonitic shale for sealing stock ponds and canal lining (BLM 1992b).

The closest deposits to the Zortman Mine are approximately 10 miles east of the Little Rocky Mountains (Jim Mitchell 1993). American Colloid Company operated a bentonite processing plant in Malta from 1978 to 1986, refining bentonite mined from an open-pit mine south of Malta in outcrops of the Bearpaw shale. There is little bentonite mining or processing occurring in this area at the present time, and the potential for future bentonite mining is uncertain since much bentonite use is associated with oil and gas production processes. Some oil and gas production wells are still active in the region, but exploration levels are quite low and new wells are not commonly being brought into production.

TABLE 3.1-1
ESTIMATED GOLD AND SILVER PRODUCTION
LITTLE ROCKY MOUNTAINS MINING DISTRICT
(in Troy ounces)

Time Period	Placer Gold	Vein Gold	Vein Silver	Disseminated Deposits Gold	Disseminated Deposits Silver
1860-1893	N/A	N/A	N/A	N/A	N/A
1893-1908	N/A	47,500	N/A	N/A	N/A
1908-1942	N/A	312,500	N/A	N/A	N/A
1928-1948	326	N/A	N/A	N/A	N/A
1946-1977	N/A	20,000	1,500,000	10,500	25,000
1979-1987	-	-	-	543,900	1,214,600
1988	-	-	-	111,100	247,400
1989	-	-	-	106,400	223,800
1990	-	-	-	109,600	652,170
1991	-	-	-	116,300	954,400
1992	-	-	-	113,000	771,600
1993	-	-	-	108,500	535,700
1994	-	-	-	109,500	461,200
Totals	326	380,000	1,500,000	1,328,800	5,085,870

Estimated Total Gold Produced: 1,709,126	Estimated Total Silver Produced: 6,585,870
Estimated Value of Produced Gold: $683,650,400[1]	Estimated Value of Produced Silver: $39,515,220[2]

N/A = Not Available

[1] In current dollars, with gold valued at $400/Troy ounce
[2] In current dollars, with silver valued at $6/Troy ounce

Source: BLM 1992b
Modified 1995

Clay
Other clays are found in shale deposits, including some near the Zortman and Landusky mines. While these deposits do not have the commercial application of bentonite they are valuable for use in various mining operations, particularly those where barriers are needed to prevent the migration of leachate (i.e., leach pad liners) or to prevent infiltration of surface water (i.e., reclamation covers). The reason clays provide high quality barriers is they have little ability to transmit water through the mineral layers making up the rock. A couple of clay sources have been identified by ZMI for potential use during reclamation and expanded mining operations.

3.1.7.3 Limestone

Limestone is used in the construction industry for producing lime, in mining and industrial chemical processes to control pH, and in agriculture as a soil conditioner. There are vast limestone resources in central and western Montana, much of it within the Madison Group of Mississippian-age sedimentary formations. The limestone mining that has occurred in the vicinity of the Little Rocky Mountains has typically been restricted to small, isolated quarries.

Limestone is very hard and resistant to processes of physical weathering such as freezing and thawing, or wind erosion. However, limestone is soluble in water and its dissolution provides conduits for groundwater flow, often through larger openings such as fractures and joints. In fact, the Madison Group of limestones serves as the major deep aquifer surrounding and underlying the Little Rocky Mountains (see Section 3.2.4).

Limestone has been and would continue to be used in reclamation activities for both the Landusky and Zortman mines, in the construction of drains or other facilities where material with a high net neutralization potential (i.e., reduces leachate acidity) is needed. Large outcrops of limestone occur near the Zortman and Landusky Mines which are easily recognizable as prominent cliffs and bluffs. The limestones which would be used in mining and mine reclamation activities would come from the Devonian-age Jefferson Formation.

The King Creek quarry site is located about 1/4 mile northwest of the Landusky Mine's Queen Rose pit in the NE¼ of Section 15, T25N, R24E (see Figure 2.6-3 in Section 2.6). The King Creek quarry is on private land and was previously mined by different parties. ZMI was permitted to mine about 50,000 tons of limestone from this site in 1993 for the King Creek cleanup project and for other mine operational uses. Also on the Landusky side, similar material could be mined at the Montana Gulch quarry, located in NW¼, SW¼ of Section 22, T25N, R24E. This site is on BLM administered lands within the current Landusky permit boundary.

Limestones for use in Zortman facilities and reclamation could be mined at a quarry known as "LS-1" in the NE¼, SW¼ of Section 6, T25N, R25E, approximately 1/2 mile north of the Ross Pit (see Figure 2.5-1 in Section 2.5). ZMI has estimated this source contains approximately one million tons of limestone. Limestone is also available at the site known as "LS-2" in Section 17, T25N, R25E.

3.1.7.4 Unconsolidated Surface Resources

Unconsolidated materials are found as deposits downgradient of areas which are being eroded. As shown on Figure 3.1-3, bedrock from mountainous areas is physically and chemically eroded and transported, by gravity or surface water flow, to lower areas. These materials will collect in depressions, valleys, and especially plains where surface water flow in drainages slows because of a decreased gradient. The reduced water speed causes gravel, sand, and other unconsolidated materials to drop out of the water.

Sand and gravel quarries are found on private and public land throughout this area. Ready sources of these materials are provided by the sedimentary formations which comprise the geology everywhere except in the mountain ranges. As described earlier, unconsolidated materials can be useful in construction of mine facilities, road base, in drains and even as capillary break in reclamation covers. As described in Section 3.1.8, these materials are most important to reclamation under alternatives 1 through 3, since no new waste rock would be generated that could be used in reclamation. For the expansion alternatives 4 through 7, the degree of importance of unconsolidated materials is based primarily on the volume of suitable waste rock available for use in these facilities. Because waste rock from the mine pits has to be moved and managed, it is more efficient to use this material in construction and reclamation applications where possible, thereby limiting other mining (i.e., limestone, sediments, alluvium, etc.) efforts and costs. If sufficient, suitable waste rock (i.e., "non acid generating") is available for these purposes there may be little need to mine sand and gravel from unconsolidated deposits.

3.1.7.5 Other Geological Resources

Oil and Gas

The nearest commercial oil production is the Cat Creek and Rattlesnake Butte Oil Fields in Petroleum County, approximately 50 miles south of the Zortman Mine operations.

The closest natural gas deposit is the Leroy gas field in northern Fergus County, approximately 35 miles southwest of the Little Rocky Mountains. The Bowdoin Field, located in northeastern Phillips County, has over 800 active wells, and produced over 2,700 MMCF in 1987 (Montana Department of Natural Resources and Conservation 1987).

The igneous complex of the Little Rocky Mountains provides poor potential for viable hydrocarbon deposits. However, some sedimentary formations on the flanks of the Little Rocky Mountains could serve as source and host rocks for hydrocarbons. To date, two oil exploration wells have been drilled in the Township near the Zortman Mine (T25N, R25E) with poor results.

Coal

Coal has been reported at one location in the Jurassic Morrison Formation on the flank of the Little Rocky Mountains uplift near Zortman (BLM 1992b). This coal is not considered to be a significant reserve, and there is estimated to be a very low probability for commercial development.

Paleontological Resources

Paleontological resources (vertebrate, invertebrate, and plant fossils) are present in various locations in the area surrounding the mine. These are not noted to have any particular commercial or geologic significance. The Judith River Formation contains small quantities of dinosaurs, crocodilian and turtle fossils, as well as occasional mammal remains. The Bearpaw shale, which has significant outcrops south of the Little Rocky Mountains, contains fossils of dinosaurs, fish, and invertebrate species.

Invertebrate fossils and some fish are found in Paleozoic Era formations. The Mississippian-age limestones of the Madison Group contain invertebrate fossils, as do the sedimentary units from the Devonian.

Caves

Numerous caves exist in the limestone formations of this region, many of which have been identified in the bluffs and outcrops of the Island Mountain Ranges. Caves in the limestones of the Madison Group were probably formed during a period when the seas retreated and somewhat acidic meteoric waters percolating through the rock created solution channels and cavities.

Azure Cave is a well documented site located in outcrops of the Mission Canyon limestone of the Madison Group. It is found approximately 1 mile west of the proposed Goslin Flats leach pad, about 2 miles south of the Zortman Mine. The BLM has determined that this resource has significant value due to its geologic and mineralogic features, and biologic community. Section 3.7 discusses in more detail the prominent geologic and biologic features of Azure Cave, including its designation as an Area of Critical Environmental Concern.

3.1.8 Reclamation Materials

Chapter Two described the reclamation requirements for each alternative, including the materials needed to construct reclamation covers. These reclamation covers vary, depending on the alternative and extent of reclamation anticipated, but most covers placed on potentially acid generating surfaces would include a capillary break/drainage layer. This section provides information on the sources of these materials which could be used in the capillary break, including estimated volumes available. Section 3.3.4 provides similar information on topsoil and subsoils available for use in reclamation covers.

The materials available for use as capillary break in the reclamation covers include non-acid generating waste rock from existing dumps or new mining, alluvial and colluvial gravels, limestone, and tailing from the Ruby Gulch drainage. Table 3.1-2 summarizes the sources for these materials, their locations, and estimated volumes of available material. Some of these materials have certain advantages for reclamation use, either because of their chemistry or availability, or both. However, disadvantages can also arise from using these same materials, such as disturbance of areas previously untouched by mining. These tradeoffs are more fully explored in Sections 4.1.3 through 4.1.9.

TABLE 3.1-2
RECLAMATION MATERIALS FOR CAPILLARY BREAK/DRAINAGE LAYERS

MINE	MATERIAL	SOURCE	AVAILABLE VOLUME[1] (yd^3)	COMMENTS
Zortman Mine	Limestone	LS-1	750,000	North of permit boundary and Shell Butte; haul road construction upgrade required. Little disturbance.
		LS-2	Unknown	West of town of Zortman, but within permit boundary. Undisturbed.
	"Blue" Waste Rock	New Mining	5.5 million	"Blue" waste would meet ZMI classification criteria, as described in Section 2.8.1.1
	NAG Waste Rock	New Mining	3.5 million	"NAG" waste would meet agencies classification criteria, as described in Section 2.7.2.2. Assumes syenite not suitable.
	Amphibolite Outcrop	New Mining	5 million	This material and source would only be accessed by new mining. Significant amounts of amphibolite, probably suitable for use as NAG, are just north of the OK pit.
	Historic Tailing	Ruby Gulch	600,000	Tailing in Ruby Gulch drainage. Required for removal under alternatives 3, 5, 6, and 7.
	Alluvial Gravels	Goslin Flats	1 million	Gravels in Goslin Flats could be mined for reclamation. Site presently undisturbed. Volume based on disturbance of about 200 acres.
Landusky Mine	Limestone	King Creek	Unknown	North of the existing permit boundary, in a tributary to the King Creek drainage. Haul road construction upgrade would be required. Some existing disturbance.
		Montana Gulch	400,000	Southwest of most mine facilities, but still within existing permit boundaries.
		Mine Outcrops	Unknown	Limestone and dolomite outcrops that may be encountered during mine pit expansion.
	"Blue" Waste Rock	New Mining	220,000	"Blue" waste would meet ZMI classification criteria, as described in Section 2.8.1.1
	NAG Waste Rock	New Mining	0	"NAG" waste would meet agencies classification criteria, as described in Section 2.7.2.2. Assumes syenite not suitable.

TABLE 3.1-2
RECLAMATION MATERIALS FOR CAPILLARY BREAK/DRAINAGE LAYERS
(Concluded)

MINE	MATERIAL	SOURCE	AVAILABLE VOLUME[1] (yd^3)	COMMENTS
	Other Waste Rock[2]	MT Gulch Dump	8 million	This dump is scheduled for use as backfill and/or mine materials under agency alternatives. Would require geochemical classification.
		August #2 Dump	1 million	This dump is at the head of King Creek and has been reclaimed. Waste rock contained within is from early mining; therefore, may be from oxidized zones and suitable as NAG waste.
		MT Gulch Bedrock	3-4 million	This source constitutes the material removed during construction of a drainage notch from the mine pits south to Montana Gulch. See alternatives 3, 6, and 7.
	Alluvial Gravels	Rock Creek Flat	310,000	This estimate includes subsoils from presently undisturbed area, about 55 acres in size, on private land southwest of the town of Landusky.

[1] Volume available represents best estimate.

[2] Existing facilities may provide suitable waste rock. However, material would require geochemical classification.

3.2 WATER RESOURCES AND GEOCHEMISTRY

This section describes the water resources of the project area and the mining related geochemical processes that have the potential to degrade water quality. The water resources section also serves to identify "baseline" water quality for the Little Rocky Mountains and any changes to surface water and groundwater quality that have occurred since 1979, during the 17 years of open pit mining activity.

Organization of Section

- Section 3.2.1 describes the location of the water resources study area and the rationale behind its division.
- Section 3.2.2 "Geochemistry/Acid Rock Drainage" describes the chemical and physical processes associated with mining that have the potential to adversely impact the water resources of the area. This section also describes the geochemical testing procedures and the acid generating character of the various rock types at the mines.
- Sections 3.2.3, Surface Water, and 3.2.4, Groundwater, describe the physical nature of the water resources, in the Little Rocky Mountains.
- Section 3.2.5 "Water Quality" contains a detailed drainage by drainage review of the surface water and groundwater quality conditions within the Little Rocky Mountains.
- Section 3.2.6 "Surface Water Groundwater Interaction" describes the relationship between the surface water and groundwater in the Little Rocky Mountains, identifying the pathways along which contaminants may travel.
- Having described in detail the present water quality situation in the Little Rocky Mountains, Section 3.2.7 "Beneficial Uses" identifies the location and nature of any end users of the resource. This section aims at recognizing presently impacted uses and any potential use.
- Finally Section 3.2.8 reviews water quality regulatory criteria applicable to water resources in the Little Rocky Mountains and where these criteria have been exceeded, both prior to 1979 and after 1979 during mining operations.
- Section 3.2.9 summarizes existing water quality conditions for the Little Rocky Mountains in tabular form.

3.2.1 Project Study Area

Present day mining facilities are located in the headwaters of several watersheds in the Little Rocky Mountains, as shown in Figure 1-3. Surface water drainages in the Little Rocky Mountains are divided between the Milk and Missouri rivers. The water resources study area consists of drainages and aquifers affected or with the potential to be affected by existing or proposed mine development. The study area is further divided into two sections based on whether the drainage receives recharge from either the Zortman or Landusky mining operations.

3.2.2 Geochemistry/Acid Rock Drainage

3.2.2.1 General Geochemical Processes

Cyanide heap leach gold mining sites have the potential to result in water quality degradation through two general types of geochemical processes:

- Generation of alkaline seepage - cyanide-related processes

  The normal use of cyanide, lime, and other reagents in leach mining processes generates leachates that are normally contained, but which have the potential to leak or spill from facilities into local waters and soil. Such fluids are usually high pH (9.0 or above), and may have elevated concentrations of cyanide, nitrogen, and sulfur compounds, along with elevated concentrations of some metals (i.e., iron, arsenic, molybdenum, copper, selenium). The cyanide compounds tend to break down relatively rapidly into non-toxic forms when in contact with air, water, and sunlight. Hence, most spills of cyanide compounds result in relatively short-term acute problems. However, the breakdown of some metal cyanide complexes such as copper cyanide can result in an increase in toxicity because of the release of some metal ions such as copper. In addition, some metal-cyanide compounds may remain stable in fine-grained sediments for decades. Table 3.2-1 summarizes characteristics of the various forms of cyanide potentially present at mining sites and the analytical tests employed to determine their presence. Additional details on the use of process-related chemicals are presented in Section 3.14.

- Production of acid water - ARD

  ARD problems may take years to develop but, if untreated, can lead to very long-term water quality degradation. Details on the formation of ARD are presented in the following sidebar.

TABLE 3.2-1
CYANIDE ANALYTICAL TESTS AND CHEMICAL FORMS

Name of Analytical Test	Forms of Cyanide Measured and Comments
Free Cyanide	Uncomplexed cyanide and hydrocyanic acid (CN^- and HCN). Most toxic form of cyanide.
Weak-acid Dissociable (WAD) Cyanide	Free cyanide plus the less stable complexes of cyanide, including cyanide complexes of cadmium, copper, nickel, silver, and zinc. While stable at pHs above 8.5 to 9.0, WAD cyanide complexes readily dissociate at lower pHs. Judged to be less toxic than free cyanide.
Total Cyanide	Free cyanide, WAD cyanide and most metal and organic complexes of cyanide, including highly stable complexes such as iron-cyanide and cobalt-cyanide. However, depending on concentrations and forms of cyanide present, the total cyanide test may not measure certain complexes. Not fully recovered are cyanide complexes of gold, cobalt, platinum, and palladium. Organic complexes such as cyanate and thiocyanate may not be measured in some samples.
Cyanide Amenable to Chlorination	Cyanide forms which can be oxidized by chlorination processes (used by water treatment plants and some mining operations). Test measures the difference between total cyanide concentrations before and after chlorination.
Cyanate	Measures organic cyanate (CNO^-) ions. Less toxic than free cyanide.
Thiocyanate	Measures organic thiocyanate (SCN^-) ions. Less toxic than free cyanide. Thiocyanate may form in samples containing sulfide and other forms of cyanide if samples are preserved at high pH without first removing the interfering sulfide.

NOTE: Table summarizes data from various sources, including the following:

American Public Health Association, 1989, Section 4500-CN Cyanide, in Standard Methods for the Examination of Water and Wastewater, 17th ed., American Public Health Association, Washington, DC.

Engineering-Science 1986. EPA. Appendix B, in Heap Leach Technology and Potential Effects in the Black Hills, EPA Contract No. 68-03-6289, U.S. EPA, Denver, CO, September 30, 1986.

U.S. Department of the Interior, 1986, Environmental Handbook for Cyanide Leaching Projects, Energy, Mining and Minerals Division, National Park Service, June, 1986.

ARD is a term used to describe acidic leachate, seepage, or drainage that results from the breakdown of sulfide materials, such as pyrite or fool's gold, when exposed to air and water. This breakdown or reaction of sulfide minerals occurs naturally at or near the earth's surface, as evidenced by the common presence of yellow-orange stains or deposits around exposed pieces of iron, marshy sediments, or at the edges of hot springs. ARD can also be generated in non-mining settings such as natural springs that may have pHs of near 2.0. Such springs usually are located in the vicinity of outcrops of sulfide bearing rock. Natural bacteria present in most surface sediments greatly accelerate the ARD-forming processes. These reactions yield low pH (acidic), high sulfate water that has the potential to mobilize metals (most commonly iron, copper, aluminum, manganese, zinc, arsenic, and nickel) contained in the geological materials that are contacted.

Theoretically, the formation of ARD and resulting degradation of water quality would not occur if metal-sulfide minerals remain buried in the oxygen-poor environments under which they were formed. Problems arise when these minerals react with the oxygen in air, as when they are excavated, broken up and transported to, or exposed at the earth's surface during mining. It is important to recognize that not all operations that expose sulfide-bearing rock will result in ARD. For example, acid drainage may not occur if the sulfide minerals are nonreactive, the rock contains sufficient alkaline material to neutralize any acid generated, or the climate is arid and there is insufficient rainfall infiltration to generate leachate. Mining activities increase the surface area of minerals available for reaction with water and air. As such, local surface and groundwater often show increases in dissolved and suspended constituents even without the formation of acidic conditions.

ARD has been associated with mining throughout recorded history. Indirect references to water quality degradation have been reported from mines in the Greek and Roman empires more than 2,000 years ago. Many Norwegian copper mines have documented more than 300 years of roughly continuous ARD problems.

Mine tailings, waste rock piles, drainage from underground workings and open-mine pits are the main sources of ARD at mine sites. Sulfide-rich ores that have been leached with cyanide may prove to be long-term generators of ARD. The development of ARD from mine-related sources may take years to decades before it becomes noticeable, often long after mine closure.

ARD can negatively impact the health of fish, other aquatic animals and plants in affected streams. Also, ARD can be harmful to wildlife, livestock, and humans if consumed in sufficient quantities from impacted surface or groundwater sources.

3.2.2.2 Existing Conditions

At the initiation of modern mining at Zortman/ Landusky in 1979, regulatory officials believed that ARD would not be a significant issue: "The proposed mine pits would not mine into the sulfide ore body, but rather the oxide ore body which is not conducive to acid drainage. Acid drainage is therefore, not considered a potential threat from the proposed projects." (Montana DSL Draft EIS 1979b adopted as FEIS, pg. 75-76).

However, as modern mining has progressed, water quality results have shown that geologic materials at both the Zortman and Landusky mines are presently generating acid in some areas. Additional details on the water quality impacts are presented in subsequent sections. Data from the two mines indicate that most of the major drainages show some degree of impact from mining-related activities.

Further evidence of the geochemical reactivity of the site rocks is presented in the Highwall Runoff Investigation (Shafer and Associates 1993b). This study was performed during the spring and summer of 1993 at the Zortman Mine to characterize internal pit drainage and evaluate the effectiveness of proposed bench reclamation techniques for both sulfide and oxide benches. Analysis of highwall runoff at 11 sampling stations showed pH ranges of 2.3 - 6.7 and 2.3 - 6.0 for two sampling events. As expected, the stations with the highest sulfide content yielded runoff with the lowest pH values. Six of eleven stations sampled yielded runoff with pH values below 3.0 during the first sampling event (Shafer and Associates 1993b). Similar results were reported in Schafer and Assoc. 1994.

3.2.2.3 Rock Types

The geologic materials present at the Zortman and Landusky mines are shown on Table 3.2-2a and 3.2-2b and are discussed in greater detail in Section 3.1, Geology and Section 2.8.1. This table shows rock types and relative amounts of ore and waste rock to be mined under the company proposed action. The predominant rock types at the Zortman Mine are:

- **Tertiary Intrusives** - Tertiary syenite porphyries comprise the largest percentage of rock to be mined from the Zortman pit complex, at about 65 percent of the total rock volume. Quartz monzonite is another Tertiary intrusive, making up about 6 percent of the rock mined. The Tertiary intrusives would contribute approximately 71 percent of the ore processed, with the remainder classifying as waste rock or material suitable for reclamation purposes.

TABLE 3.2-2a
ZORTMAN MINE ROCK TYPES PROPOSED FOR MINING

Relative Age and Rock Type	Percent of Rock to be Mined	Percent Ore	Percent Waste
Tertiary: Syenite Porphyries	64%	35%	29%
Precambrian: Amphibolites	13%	6%	7%
Precambrian: Felsic Gneisses	8%	6%	2%
Tertiary: Monzonite	7%	5%	2%
Quartzite, Breccia, & Cambrian Shale, or Unclassified	8%	5%	3%
Total	100%	57%	43%

TABLE 3.2-2b
LANDUSKY MINE ROCK TYPES PROPOSED FOR MINING

Relative Age and Rock Type	Percent of Rock to be Mined	Percent Ore	Percent Waste
Tertiary: Porphyries and Breccias	81%	38%	43%
Paleozoic: Sedimentary rock	13%	9%	4%
Archean: Metamorphics	3%	2%	1%
Unclassified	4%	3%	1%
Total[1]	101%	52%	49%

[1] Total exceeds 100% due to rounding of percentages.

- **Precambrian Metamorphics** - Approximately 21 percent of the rock to be mined would consist of metamorphic rocks from the Archean, primarily amphibolites (13 percent) and felsic gneisses (8 percent). About half of this material would be suitable for ore processing, with the remainder classifying as waste rock or material suitable or reclamation purposes.

In addition to the rock types listed above, minor amounts (8 percent) of quartzite, breccia, and Cambrian shale and other unclassified lithologies would be mined, with approximately 5 percent of this material suitable as ore.

Geologic materials present at the Landusky Mine are shown on Table 3.2-2b. This table shows rock types and relative amounts of ore and waste rock proposed to be mined. The predominant rock types at the Landusky Mine are:

- **Tertiary Intrusives** - ZMI has estimated that 81 percent of the rock mined would consist of Tertiary felsic porphyries and associated breccias.

- **Paleozoic Sediments** - Approximately 16 percent of the rock to be mined would be from Paleozoic sedimentary formations, with approximately 9 percent of this material containing sufficient amounts of precious metals to be worth processing as ore. The bulk of the Paleozoic rock is unmineralized Emerson Formation, consisting of limestones, marls, and calcareous shales which would all be handled as material suitable for reclamation and construction purposes. These lithologies show less alteration, less mineralization and have lower average sulfur content than the igneous rocks.

- **Archean Metamorphics** - About 3 percent of the rock to be mined would be composed of approximately equal amounts of schists, gneisses and amphibolites. Archean rocks have comprised a significant portion of the rocks mined at Landusky in recent time, but the proposed mining would result in removal of greater amounts of Tertiary and Paleozoic rocks as illustrated in Table 3.2-2b.

3.2.2.4 Geochemical Testing

The Saskatchewan Environments' Mine Rock Guidelines (1992) provided guidance methods for mine rock characterization. Geochemical testing has been performed on over two thousand samples of ore, spent ore, waste rock, and other unmineralized local rock types at both the Zortman and Landusky mines. These tests can be useful in determining which geologic materials may act to neutralize acid production or which materials may generate acid upon exposure to air and water. Results were used to evaluate the adequacy of ZMI's definition of non-acid generating (NAG) waste rock to see if the criteria should be modified. The discussion provided in Section 3.2.2.6 includes rationale as to why ZMI's proposed definition is too general and the agencies' previous definition, developed in the Landusky EA, is too restrictive.

Total sulfur

Total sulfur gives some indication as to the abundance of reactive sulfides associated with a certain rock. If all sulfur is reactive then total sulfur can be used to evaluate its acid producing potential (AP).

Paste pH testing

Paste pH evaluates the existing pH of the rock material and can assess the acidity due to dissolution of reaction products that have accumulated in the rock surfaces. (The "pH" is an expression of the acidity or alkalinity of the material, on a scale of 1 to 14, with 1 being most acidic, and 14 most alkaline; 7 is considered neutral). A paste pH above 7.0 may be indicative of high percentages of alkaline minerals. Such high pHs might also be seen in alkaline rock with sulfide that has not yet reacted.

Static testing

Static tests typically involve measurement of the Acid Neutralizing Potential (ANP or NP) of a sample, as well as its Acid Generating Potential (AGP or AP). The NP is a reflection of the abundance of minerals that consume acid, such as most carbonate minerals, some hydroxides, and silicates such as feldspars, amphiboles, and clays. The balance or difference between NP and AP indicates the net tendency of a material to either produce or consume acid. The Net Neutralization Potential (NNP) is defined as the difference between the NP and the AP. Theoretically, NNP values are negative for potentially acid-forming samples and are positive for potentially acid consuming samples.

Static test results are interpreted in several ways in the geochemical literature. Some of the most commonly used criteria, and the criteria used in this evaluation, are shown on Table 3.2-3. Due to inherent inconsistencies in interpreting static data, samples with an NNP greater than +20 and 3 times more NP than AP, i.e. an NP:AP ratio greater than 3, are conservatively considered to be those with a low potential to generate acid. Samples with an NP:AP ratio of less than 1 and an NNP of less

TABLE 3.2-3
EVALUATION CRITERIA FOR ACID-BASE ACCOUNTING ANALYSES

	B C AMD Task Force[5]	
	NNP[1]	NP[2]:AP[3]
Strong Acid Generation Potential		
Group 1	< -20 $TCaCO_3$/KT[4]	< 1.0
Uncertain Acid Generation Potential		
Group 2	-20 $TCaCO_3$/KT ≤ NNP ≤ 20 $TCaCO_3$/KT	1.0 ≤ NP:AP ≤ 3.0
Low Acid Generation Potential		
Group 3	> 20 $TCaCO_3$/KT	NP:AP > 3.0

		Agency Evaluation Criteria[6]		
	Paste PH	NNP	NP:AP	Total Sulfur
Group 1	< 6	< -20 $TCaCO^3$/KT	< 1.0	> 1%
Group 2	N/A	-20 T/KT ≤ NNP < O	N/A	0.2% ≤ S_{TOT} ≤ 1%
Group 3	≥ 6	≥ 0 T/KT	≥ 1	≤ 0.2%

1 - Net neutralization potential
2 - Acid neutralization potential
3 - Acid generating potential
4 - Acid generating potential per kiloton of waste
5 - British Columbia Acid Mine Drainage Task Force (1989)
6 - Miller (1995)

than -20 are considered to have a strong potential to generate acid and therefore rock groups which showed a higher acid production risk were evaluated using kinetic testing. The geochemical reactivity of samples which fall in between these two categories is uncertain and kinetic testing should be used to help confirm or refute static results (B.C. AMD Task Force, 1989; Saskatchewan Environment, 1992; and Hutchison and Ellison, 1992). These criteria should be considered as rough guidelines for prediction of net acid generation from specific geologic materials. The following quotation is instructive:

> *"Despite the theoretical simplicity, static tests can not be used to predict the quality of drainage emanating from waste materials at any future time. Acid generation processes and therefore drainage quality are time-dependent and functions of a large number of complex factors such as mineralogy, rock structure and climate. For this reason, static tests should be treated as a qualitative predictive method; that is, they can only indicate whether or not there is a potential for generation of net acidity at some unknown time" (B.C. AMD Task Force 1989)*

Static data for Zortman/Landusky geologic materials suggest that more refined testing is needed to interpret static results from samples that fall within the uncertain acid generation potential category (see Table 3.2-3). That is, samples having NNP values less than +20 and an NP:AP ratio between 1 and 3 should be tested for their potential to generate acid over time. Static results for Zortman/Landusky indicate that there is acid producing potential especially for the igneous rock types, therefore kinetic testing was performed to further assess the potential.

Kinetic Testing

The objective of kinetic testing is to assess the acid generation potential with greater confidence. The goal is to develop a list of readily applicable rock characteristics that can be used to identify rock that will not generate acid and distinguish those that will generate significant quantities of acid. Geochemical kinetic tests involve accelerated weathering of samples under laboratory controlled conditions by leaching moist, hot air through the material in a cell and analyzing the leachate which exits the cell. These leach cycles can be conducted indefinitely but are usually performed for at least 20 weeks. These are referred to as humidity cells in the literature. Whereas static tests provide some information on overall potential acid generation independent of time, kinetic tests explicitly define reaction rates through time under the specific conditions of the test that is applied. However, general geochemical literature does not clearly demonstrate that kinetic testing is capable of providing highly accurate or precise long-term predictions about acid generation and metal liberation. Such tests provide a relatively short-term, qualitative appraisal of the potential oxidation of the samples in question. Kinetic test data often poorly predict actual future water quality numbers because the minerals such as carbonate that supply buffering (i.e., reduce acidity) generally react rapidly, while the minerals such as pyrite that supply acidity react relatively slowly. Many tests are only indicative of the rapid reactions.

Most short-term, kinetic tests are conducted at private laboratories, usually for a 20-week period. These tests are conducted on relatively small samples (250 to 1000 grams) of crushed, sieved, smaller-grained material, and leached with large quantities of water for each rinse cycle. Simulation of the effects of average precipitation on the coarser-sized material is not attempted. Therefore, these tests only provide semi-quantitative information on drainage water quality because they do not attempt to reproduce site conditions. Details of the short-term (20-week) test method used are described in the Zortman Mine Expansion Application, Vol. 6, Appendix 12; and Saskatchewan Environment, 1992 page 5-28 and 5-29. This test method is referred to in the literature as the Modified Humidity Cell.

Long-term, laboratory kinetic tests that attempt to simulate field conditions especially the annual precipitation and particle size, will often leach larger samples (kilograms) of run-of-mine material for over a year. Since these tests are more expensive, they are conducted at the minesite where larger samples can be more easily accommodated and leachates can be analyzed at lower cost. Such tests may yield more reliable reaction rate data but may not simulate long-term water quality because water to rock volumes are not characteristic of field conditions. An example of the method used for these tests is given in Saskatchewan Environment, 1992 page 5-29 to 5-31. This test method is referred to as the SRK Modified Humidity Cell.

On-site, pilot-scale, field tests are performed to confirm the potential to generate acidity, determine the rates of acid generation, sulphide oxidation, neutralization, and metal depletion and to test control/treatment techniques. This type of long-term, field-scale test is more likely to yield reliable reaction rate data and predictions of long-term water quality than the previously mentioned lab tests.

All three types of kinetic testing were conducted for the Zortman/Landusky materials. Short and long-term testing is completed.

3.2.2.5 Ore Test Results

Static Testing

Static tests were performed on 275 Zortman ore samples. The results are summarized in Table 3.2-4. Similar static data for Landusky ore samples are shown on Table 3.2-5. These data indicate that most of the Zortman and Landusky ores have a strong potential to generate acid. Other results indicate that ore from the reasonably foreseeable Pony Gulch area contains substantial net neutralizing potential in the 500 to 800 T $CaCO_3$/kT ore range. (Results of static tests on Pony Gulch samples are available in project files at the DEQ in Helena).

Considerable caution must be applied when using mean ABA or percent sulfur values; they often mask extremely different individual values. Also, it is unrealistic to perform a mass balance calculation of mean AP versus mean NP to determine whether a mix of lithologies would be acid generating or not. This approach assumes that all of the materials react, and at the same rate. This is almost never the case.

Kinetic Testing

Short-term (20-week) kinetic testing was performed on several types of spent ore to evaluate the potential of these materials to produce acid and release metals. These results confirmed the indication given by the static results that all ore would be acid-forming either initially or after an undefined period of time. Blended amendments did not succeed in affecting the acid production significantly, but only served to delay the time before acidic conditions would prevail. This is demonstrated in the field because leachates from some existing rinsed leach pads already show a tendency toward acidity. The exception was the ore associated with the Pony Gulch deposit. This material was found to have significant buffering capacity and, when layered in the cell with the reactive ore, the cell did not produce acidic leachate under the conditions of the short-term kinetic test.

Unamended sulfide and sulfide:oxide blended spent ore are likely to release elevated metal concentrations where the pH drops below about pH 4.0. Spent ores, whether amended or not, may release elevated concentrations of nitrates and selected metals that are mobile at alkaline pHs, i.e., arsenic, chromium, selenium, molybdenum, uranium. These metals were not determined in the humidity cell analyses.

These kinetic test results indicate that, immediately after cessation of pad flushing, spent ores will likely have alkaline pHs considerably above pH 7.0. However, subsequent leachates may become acid as remnant sulfides react.

3.2.2.6 Waste Rock Test Results

Static Testing

A series of tests were performed on approximately 558 Zortman and 649 Landusky waste rock samples. Two dominant rock types, syenite and amphibolite, were investigated with more intensity because they comprise the majority of waste rock that would be produced for the mine expansion. Results are summarized in Tables 3.2-6, 3.2-7, 3.2-7a and 3.2-7b. These data were generated from widely-spaced development drill holes, so there is an inherent margin of error in some of the calculations. These tables are not meant to indicate that the materials and volumes listed will behave or react chemically in any specific manner. The tables are provided to give the reader an idea of relative abundance and average net neutralizing potential (NNP) for each sample group. The zeros given in some categories reflect the assumption that only a limited amount of that category waste is present. It is likely that more closely-spaced developmental drilling will confirm the presence of these less abundant waste rock types.

In general, material from Landusky has a slightly higher average total sulfur and, because of the greater presence of carbonate rock types, a higher average NP and NNP than that from Zortman. Results also indicate that, when both mine sites are considered together, three geochemical groupings exist based on rock type, iron sulfide types and occurrences, total sulfur content, paste pH, and NNP:

1. The Archean amphibolite/mafic gneiss and Paleozoic sedimentary shale, limestone, and dolomite

2. The Tertiary igneous syenite porphyry

3. The other Tertiary igneous rocks (breccia, monzonite, trachyte), and the Archean quartzites and felsic gneisses

TABLE 3.2-4
AVERAGE NNP VALUES BY LITHOLOGY AND PERCENT TOTAL SULFUR FOR ZORTMAN ORE

Lithology	% Total Sulfur	Class Average NNP (t/1000t)	n	Estimated Total Tons	% Total Quantity
Syenite Porphyry	<0.2	0	41	0	0.0%
	0.2-0.5	-9	22	23,000,900	28.8%
	>0.5	-50	78	27,002,000	33.8%
Subtotal		-31	141	50,002,900	62.5%
Monzonite	<0.2	-1	16	0	0.0%
	0.2-0.5	-10	12	2,020,600	2.5%
	>0.5	-66	18	4,215,800	5.3%
Subtotal		-48	46	6,236,400	7.8%
Felsic Gneiss	<0.2	-1	5	0	0.0%
	0.2-0.5	-7	6	2,614,600	3.3%
	>0.5	-114	38	6,100,700	7.6%
Subtotal		-82	49	8,715,300	10.9%
Amphibolite	<0.8	4	15	4,571,700	5.7%
	>0.8	-53	12	3,740,500	4.7%
Subtotal		-22	27	8,312,200	10.4%
Quartzite	<0.2	0	6	0	0.0%
	0.2-0.5	22	3	505,500	0.6%
	>0.5	-46	3	1,179,500	1.5%
Subtotal		-26	12	1,685,000	2.1%
Unclassified	--	--	--	5,048,200	6.3%
TOTAL		-37	275	80,000,000	

Volume weighted NNP

Source: ZMI Drilling Programs, 1990 and 1993.
ZMI 1995

TABLE 3.2-5
AVERAGE NNP VALUES BY LITHOLOGY AND PERCENT TOTAL SULFUR FOR LANDUSKY ORE

Lithology	% Total Sulfur	Class Average NNP (t/1000t)	n	Estimated Total Tons	% Total Quantity
Syenite Porphyry	<0.2	2	90	0	0.0%
	0.2-0.5	-7	67	1,571,700	20.7%
	>0.5	-35	240	3,667,200	48.3%
Subtotal		-27	397	5,238,900	68.9%
Monzonite	<0.2	NS	NS	0	0.0%
	0.2-0.5	-9	2	0	0.0%
	>0.5	-18	4	0	0.0%
Subtotal		--	6	0	0.0%
Trachyte Porphyry	<0.2	2	47	0	0.0%
	0.2-0.5	-8	13	182,700	2.4%
	>0.5	-36	51	182,700	2.4%
Subtotal		-22	111	365,400	4.8%
Felsic Gneiss	<0.2	4	7	0	0.0%
	0.2-0.5	-8	6	60,700	0.8%
	>0.5	-82	22	242,900	3.2%
Subtotal		-67	35	303,600	4.0%
Emerson Shale	<0.2	4	2	132,600	1.7%
	0.2-0.5	-5	1	796,000	10.5%
	>0.5	-51	9	398,000	5.2%
Subtotal		-18	12	1,326,600	17.5%
Unclassified	--	--	--	365,500	4.8%
TOTAL		-26	561	7,600,000	100.0%

Volume weighted NNP

Source: ZMI 1993 Drilling Program.

TABLE 3.2-6
AVERAGE NNP VALUES BY LITHOLOGY AND PERCENT TOTAL SULFUR FOR ZORTMAN WASTE ROCK

Lithology	% Total Sulfur	Class Average NNP (t/1000t)	n	Estimated Total Tons	% Total Quantity
Syenite Porphyry	<0.2	1	74	3,714,700	6.2%
	0.2-0.5	-7	63	16,406,010	27.3%
	>0.5	-38	204	20,051,790	33.4%
Subtotal		-22	341	40,172,500	67.0%
Monzonite	<0.2	2	36	0	0.0%
	0.2-0.5	-7	26	1,569,600	2.6%
	>0.5	-27	47	1,569,600	2.6%
Subtotal		-17	109	3,139,200	5.2%
Felsic Gneiss	<0.2	2	17	0	0.0%
	0.2-0.5	-3	23	718,700	1.2%
	>0.5	-67	33	1,676,900	2.8%
Subtotal		-47	73	2,395,600	4.0%
Amphibolite	<0.8	13	12	5,244,400	8.7%
	>0.8	-31	8	4,290,900	7.2%
Subtotal		-7	20	9,535,300	15.9%
Quartzite	<0.2	2	7	0	0.0%
	0.2-0.5	-7	4	500,000	0.8%
	>0.5	-85	4	768,700	1.3%
Subtotal		-54	15	1,268,700	2.1%
Unclassified	--	--	--	3,488,700	5.8%
TOTAL		-21	558	60,000,000	

Volume weighted NNP

Source: ZMI Drilling Programs, 1990 and 1993.
ZMI 1995

TABLE 3.2-7
AVERAGE NNP VALUES BY LITHOLOGY AND PERCENT TOTAL SULFUR FOR LANDUSKY WASTE ROCK

Lithology	% Total Sulfur	Class Average NNP (t/1000t)	n	Estimated Total Tons	% Total Quantity
Syenite Porphyry	<0.2	7	69	100,000	1.4%
	0.2-0.5	-3	144	633,400	9.0%
	>0.5	-20	265	5,331,600	76.2%
Subtotal		-17	478	6,065,000	86.6%
Trachyte Porphyry	<0.2	0	2	0	0.0%
	0.2-0.5	-6	4	65,000	0.9%
	>0.5	-36	23	151,600	2.2%
Subtotal		-27	29	216,600	3.1%
Felsic Gneiss	<0.2	15	12	0	0.0%
	0.2-0.5	-4	12	0	0.0%
	>0.5	-64	32	0	0.0%
Subtotal		--	56	0	0.0%
Amphibolite	<0.2	58	4		0.0%
	0.2-0.5	59	5	0	0.0%
	>0.5	-12	1	0	0.0%
Subtotal		--	10	0	0.0%
Quartzite	<0.2	0	1	0	0.0%
	0.2-0.5	-5	3	15,000	0.2%
	>0.5	-53	10	55,600	0.8%
Subtotal		-43	14	70,600	1.0%
Emerson Shale	<0.2	3	28	0	0.0%
	0.2-0.5	-4	23	261,100	3.7%
	>0.5	-24	11	274,000	3.9%
Subtotal		-14	62	535,100	7.6%
Unclassified	--	--	--	112,700	1.6%
TOTAL		-18	649	7,000,000	100.0%

Volume weighted NNP

Source: ZMI 1993 Drilling Program
ZMI 1995

TABLE 3.2-7a
LANDUSKY MINE WASTE ROCK SUMMARY OF TOTAL SULFUR, PASTE pH, AND NNP DATA BY LITHOLOGY

		Total Sulfur (%)			Paste pH (units)			NNP (T/KT)		
Lithology	n	Min	Max	Average	Min	Max	Average	Min	Max	Average
Syenite	500	0.00	2.87	0.58	3.4	9.6	8.0	-84.7	73.5	-10.7
Monzonite	29	0.01	1.97	0.46	5.5	9.4	8.1	-61.6	53.7	-4.5
Trachyte	31	0.15	2.50	1.08	5	9.2	7.6	-73.1	68.3	-26.5
Felsic Gneiss	56	0.01	6.37	1.30	3.9	9.3	6.5	-199.1	88.7	-32.9
Amphibolite	13	0.02	0.54	0.22	7.9	9.1	8.6	-11.9	86.9	48.9
Emerson Shale	70	0.01	1.69	0.29	6.9	9.2	8.5	-32.2	678.8	138.5
Quartzite	14	0.18	3.70	1.41	6.3	8.7	7.9	-110.6	-0.5	-39.2
Breccia	3	3.00	15.30	9.96	2.7	4.4	3.4	-478.1	-190.0	-311.3
ALL SAMPLES	716	0.00	15.30	0.68	2.7	9.6	7.9	-478.1	678.8	1.0
All samples with ZMI proposed cutoff for Alternatives 2 and 4	139	0.00	0.19	0.09	5.4	9.5	8.3	-5.7	678.8	47.7
All syenite samples with agency cutoffs*	57	0.00	0.19	0.08	6.6	9.5	8.5	0.7	71.5	9.2
All amphibolite and sedimentary samples with agency cutoffs*	68	0.01	0.73	0.20	6.9	9.2	8.5	2.7	678.8	142.2

Source: ZMI Data, 1993
* Alternatives 3, 5, 6, and 7

TABLE 3.2-7b
ZORTMAN MINE WASTE ROCK SUMMARY OF TOTAL SULFUR, PASTE pH, AND NNP DATA BY LITHOLOGY

Lithology	n	Total Sulfur (%)			Paste pH (units)			NNP (T/KT)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
Syenite	343	0.01	9.66	0.86	3.80	10.00	7.7	-301.0	20.0	-23.5
Monzonite	105	0.00	3.29	0.54	4.10	9.40	7.6	-102.0	4.9	-13.6
Trachyte	2	0.57	1.67	1.12	5.30	7.60	6.5	-52.2	-13.4	-32.8
Felsic Gneiss	73	0.01	6.53	1.10	3.30	9.40	7.0	-207.1	40.0	-30.5
Amphibolite	28	0.01	4.09	0.59	6.50	9.00	8.1	-124.0	94.1	6.3
Quartzite	15	0.01	4.70	0.98	n/a	n/a	n/a	-130.0	13.0	-23.4
Breccia	2	0.39	1.63	1.01	3.50	4.70	4.1	-50.7	-12.0	-31.4
ALL SAMPLES	568	0.00	9.66	0.82	3.30	10.00	7.59	-301.00	94.09	-21.2
All samples with ZMI proposed cutoff for Alternatives 2 and 4	147	0.00	0.19	0.08	5.30	10.00	8.4	-6.6	80.9	2.9
All syenite samples with agency cutoffs*	44	0.01	0.17	0.07	7.1	10.0	8.6	0.0	15.0	2.7
All amphibolite and sedimentary samples with agency cutoffs*	18	0.01	0.75	0.16	8.1	8.6	8.3	1.0	80.9	22.0

Source: ZMI Data, 1993
*Alternatives 3, 5, 6, and 7

4. The Bureau collected samples for static testing. Results were consistent with previous testing done by ZMI (Bureau of Mines, 1996).

Zortman Short-term Kinetic Testing

Series humidity cells. Short-term kinetic testing was conducted for 20 weeks for 16 humidity cells. Eight series humidity cells were conducted to evaluate the applicability of blending certain rock types with others and to simulate the proposed and alternative reclamation covers as mitigation for acid rock drainage. Two dominant rock types were investigated because, in combination, they comprise the majority of waste rock that would be produced for the mine extension. Humidity cells, configured in series, were mixtures of the two major waste rock types (Figure 3.2-1). These mixes varied in reactivity from very reactive high sulfur waste to relatively unreactive neutral waste proposed for use in reclamation covers. Tables 3.2-8a and 3.2-8b tabulate results from both the short- and long-term tests.

The uses of limestone or waste as a cover and/or an underdrain were also investigated. Cells with mixes of different rock types were placed in series. Leachate exiting from the bottom of one cell was allowed to leach into the next cell and so on until the leachate exited the final cell. Leachate samples were taken after passing through each cell to evaluate the effect of each portion of the series. Lower sulfate and higher pH results indicated that the use of a low sulfur waste as a cover would be preferred rather than the limestone. Results for the low sulfur waste cover with a limestone underdrain were most favorable (Figures 3.2-2a and 3.2-2b).

Only one cell evaluated blending, Cell 22. This cell was 60 percent amphibolite, 30 percent syenite and 10 percent monzonite. Results, although not conclusive, did indicate that if a considerable amount of amphibolite could be blended with the more reactive rock, some buffering would occur. Approximately 5 million tons of amphibolite is available outside the minable portion of the Zortman ore body. Therefore, this mitigation may be available if needed. A more detailed discussion on the kinetic testing is in Volume 6, Appendix 12 of the Zortman Mine Expansion Application.

Single humidity cells. Single humidity cells were used to evaluate the individual reactivity of the amphibolite/mafic gneiss and syenite rock types. These two dominant rock types were investigated because, in combination, they comprise the majority of waste rock that would be produced from the mine expansion. Eight single humidity cells were conducted (Figure 3.2-3). The rock types of these cells were not mixed, but were tested as individual rock types.

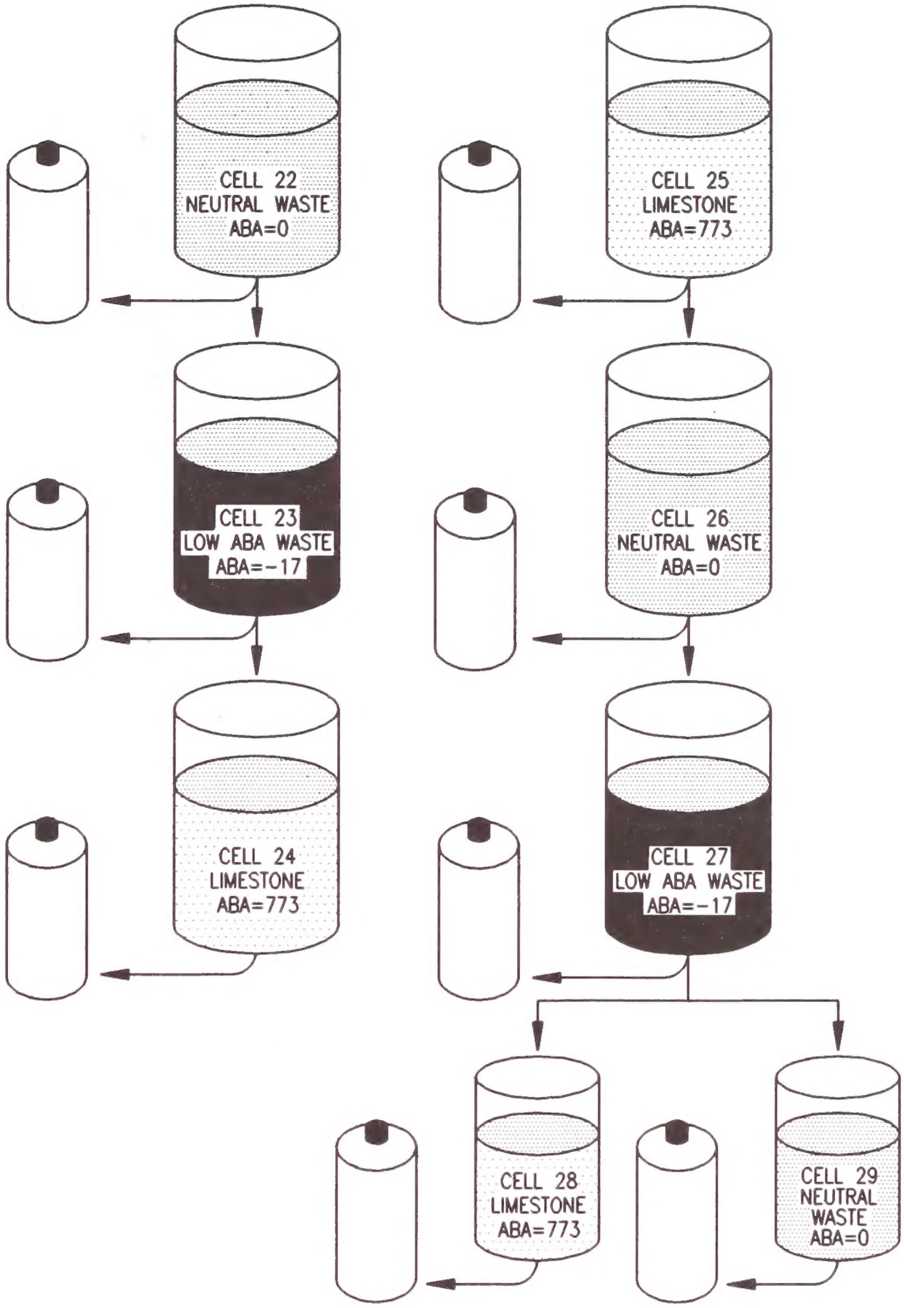
Syenite ranged from 1 to 2 wt % total sulfur in four short-term tests. This range was used to establish the upper total sulfur bracket for this rock type, with respect to suitability as reclamation material. It was found that three syenite samples were reactive and produced lower pH leachates, detectable metal levels, and substantial sulfate either initially or during the 20-week duration of the testing. The material in the one cell (#31, in Table 3.2-8a) which reacted slowly had a relatively high ANP (NP = 47) which maintained the cell at a pH of around 6.0. More detailed discussion is given in Volume 6, Appendix 12 of the Zortman Mine Expansion Application. After review of the results from this group of tests, it was determined that, to better define syenite reactivity, a lower range of sulfur values be tested for an extended duration (cells HC-42, 43, 44). Results are discussed in following sections.

Amphibolites tested had sulfur values ranging from 0 to 0.7 wt % (cells 22, 34, 35, 36). Results indicated that for all four cells, very low production of sulfate was evident indicating little acid production, and that the alkalinity buffered the pH of the cells between 6 and 7. Levels of metals in leachates collected from the amphibolites ranged from undetected to low.

Subsequently, a series of 5 replicate humidity cells were conducted using an independent contractor. Results from these tests supported conclusions previously made (Chemac, 1996).

Zortman Long-term Kinetic Testing

Fifteen additional long-term kinetic tests were conducted over a period of 72 weeks (cells HC-42 through HC-56). Results from long-term testing are compared with the short-term testing in detail in Miller (1995). Cells were leached continuously for the first 23 weeks, allowed to rest for approximately 27 weeks, and then leached again for another 22 weeks. The rock types tested included: syenite, breccia, monzonite, and trachyte; and metamorphic rocks: amphibolite, mafic gneiss, and felsic gneiss. Figures 3.2-4 through 3.2-8 have combined both the short- and long-term test results for comparison with static data. Tables 3.2-8a and 3.2-8b tabulate results from both the short- and long-term tests. All cells, both short-and long-term tests, which met the following four criteria, did not develop acid pHs, produce substantial sulfate, or release high levels of metals in the latter half of the leaching sequence (Figures 3.2-7 and 8):



HUMIDITY CELL TESTS CONDUCTED IN SERIES TO SIMULATE PROPOSED SELECTIVE HANDLING AND LAYERING PROPOSALS

SOURCE: ZORTMAN EXTENSION PROJECT – GEOCHEMICAL KINETIC TESTING OF WASTE ROCK

SHORT TERM
SERIES HUMIDITY CELLS

ZOR-WR03

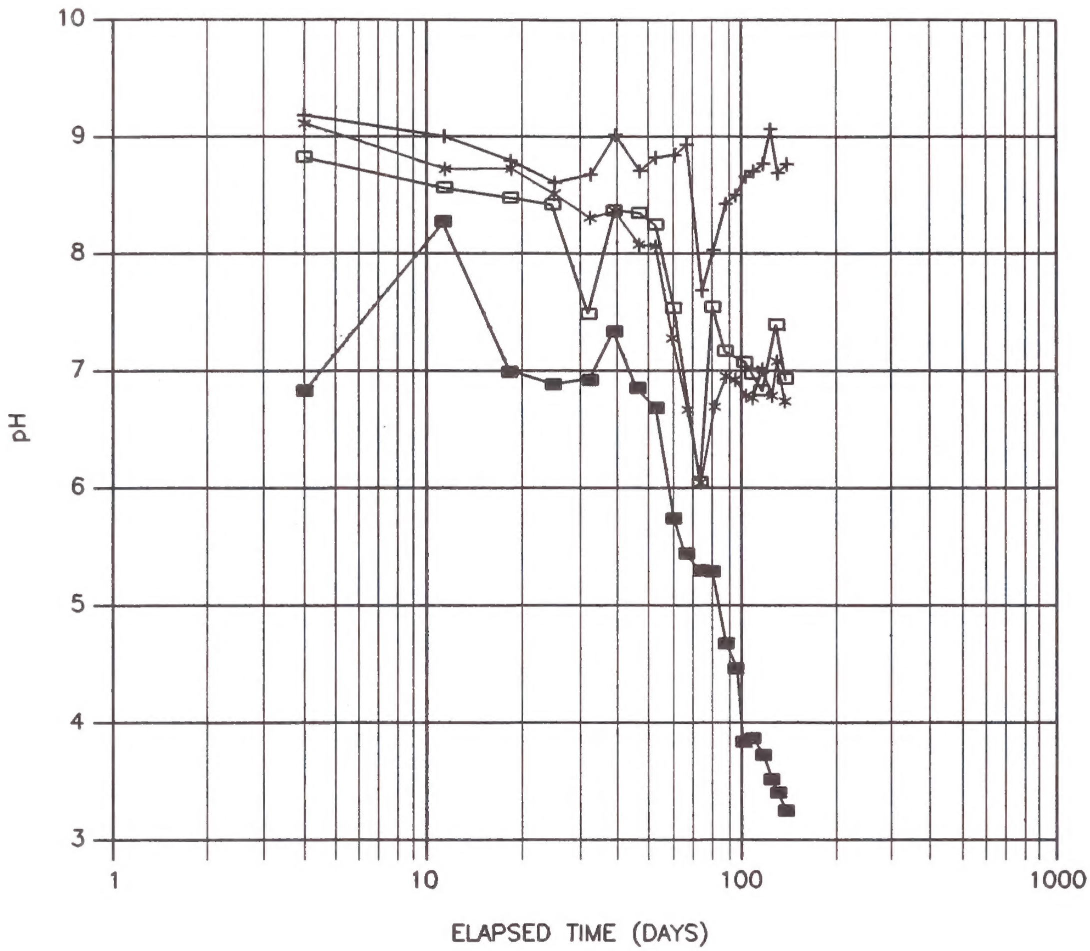
FIG. 3.2-1

TABLE 3.2-8a
KINETIC TESTING - ZORTMAN WASTE ROCK
SINGLE CELLS SHORT- AND LONG-TERM

Sample description		Cell #	Duration	NP (T/KT)	AP (T/KT)	Total Sulfur (percent)	Paste pH Standard Units	Final pH Standard Units	Sulfate Production Latter Portion of Test (mg/kg/cycle)	NNP (T/KT)	NP/AP (T/KT)
Amphibolite	250 g	36	20 weeks	7	6	0.2	7.2	7.5	7.34	1	1
Amphibolite	250 g	34	20 weeks	24	0	0.01	8.4	7.4	0.97	24	80
Amphibolite	250 g	35	20 weeks	6	0	0.01	5.7	6.2	3.01	6	20
Amphibolite	60% of 750 g	22	20 weeks	21	21	0.67	6.4	6.4	0.76	0	1
Amph\mafic gneiss	2.08 kg	HC-47	45 weeks	120	26	0.82	7.9	7.2	11.63	94	5
Amph\mafic gneiss	2.16 kg	HC-46	45 weeks	67	8	0.24	8.3	7.2	5.27	59	9
Amph\mafic gneiss	2.16 kg	HC-45	45 weeks	85	4	0.14	8.1	7.0	2.36	81	20
Breccia	2.03 kg	HC-53	56 + weeks	0	12	0.39	3.5	3.5	6.71	-12	0
Breccia	2.27 kg	HC-54	56 + weeks	0	51	1.63	4.7	3.1	112.25	-51	0
Felsic gneiss	2.25 kg	HC-55	56 + weeks	49	12	0.37	8.3	7.7	3.19	37	4
Felsic gneiss	2.45 kg	HC-56	56 + weeks	3	52	1.66	4.6	3.2	120.5	-48	0
Monzonite	1.57 kg	HC-50	56 + weeks	0	8	0.25	5.2	4.1	18.63	-8	0
Monzonite	1.98 kg	HC-51	56 + weeks	0	12	0.39	5.6	4.0	15.01	-12	0
Monzonite	2.25 kg	HC-52	56 + weeks	0	25	0.79	4.1	3.2	75.13	-25	0
Syenite	2.19 kg	HC-42	45 weeks	7	5	0.17	7.1	6.8	13.45	2	1
Syenite	2.21 kg	HC-44	45 weeks	28	24	0.78	6.2	6.6	38.45	4	1
Syenite	2.31 kg	HC-43	45 weeks	14	10	0.31	7.9	6.6	17.81	5	1
Syenite	250 g	31	20 weeks	47	62	1.98	6.8	6.0	7.72	-16	1
Syenite	250 g	32	20 weeks	17	44	1.41	2.8	4.2	49.71	-27	0
Syenite	60% of 250 g	30	20 weeks	13	30	0.96	2.8	3.3	145.53	-17	0
Syenite	60% of 750 g	33	20 weeks	22	67	2.14	3.8	4.2	40.19	-45	0
Trachyte	2.12 kg	HC-48	56 + weeks	4	18	0.57	7.6	6.2	9.56	-13	0
Trachyte	2.14 kg	HC-49	56 + weeks	0	52	1.67	5.3	3.5	42.44	-52	0

TABLE 3.2-8b
KINETIC TESTING - ZORTMAN WASTE ROCK
SERIES CELLS SHORT-TERM

Sample description	Cell #	Duration	NP (T/KT)	AP (T/KT)	Total Sulfur (percent)	Paste pH Standard Units	Final pH Standard Units	Sulfate Production Latter Portion of Test (mg/kg/cycle)	NNP (T/KT)	NP/AP (T/KT)
WASTE COVER AND LIMESTONE UNDERDRAIN										
Amphibolite 60% of 750 g	22 cover	20 weeks	21	21	0.7	6.4	6.4	0.76	0	1
Syenite 60 % of 500 g	23 reactive waste		13.0	30.0	0.96	5.8	6.8	2.84	-17.0	0.4
Limestone 250 g	24 underdrain		773	0	0		8.74	4.93	773	773
LIMESTONE COVER AND LIMESTONE UNDERDRAIN										
Limestone	25 cover	20 weeks	773	0	0		9.32	0	773	773
Amphibolite 60 % of 1000 g	26 neutral waste		21.0	21.0	0.67	6.3	8.9	0.54	0.0	1.0
Syenite 60 % of 750 g	27 reactive waste		13.0	30.0	0.96	2.9	5.6	60.29	-17.0	0.4
Limestone	28 underdrain		773	0	0		6.72	63.14	773	773
LIMESTONE COVER AND WASTE UNDERDRAIN										
Limestone	25 cover	20 weeks	773	0	0		9.32	0	773	773
Amphibolite 60 % of 1000 g	26 neutral waste		21.0	21.0	0.67	6.3	8.9	0.54	0.0	1.0
Syenite 60 % of 750 g	27 reactive waste		13.0	30.0	0.96	2.9	5.6	60.29	-17.0	0.4
Amphibolite 60% of 250 g	29 neutral waste		21.0	21.0	0.67	6.7	6.9	65.3	0.0	1.0



SOLUTION pH FROM HUMIDITY CELLS SIMULATING SELECTED ALDER GULCH WASTE ROCK CAPPING AND BASE LAYER ALTERNATIVES

LEGEND

NO CAP

NEUTRAL CAP/LS BASE

LS CAP/ LS BASE

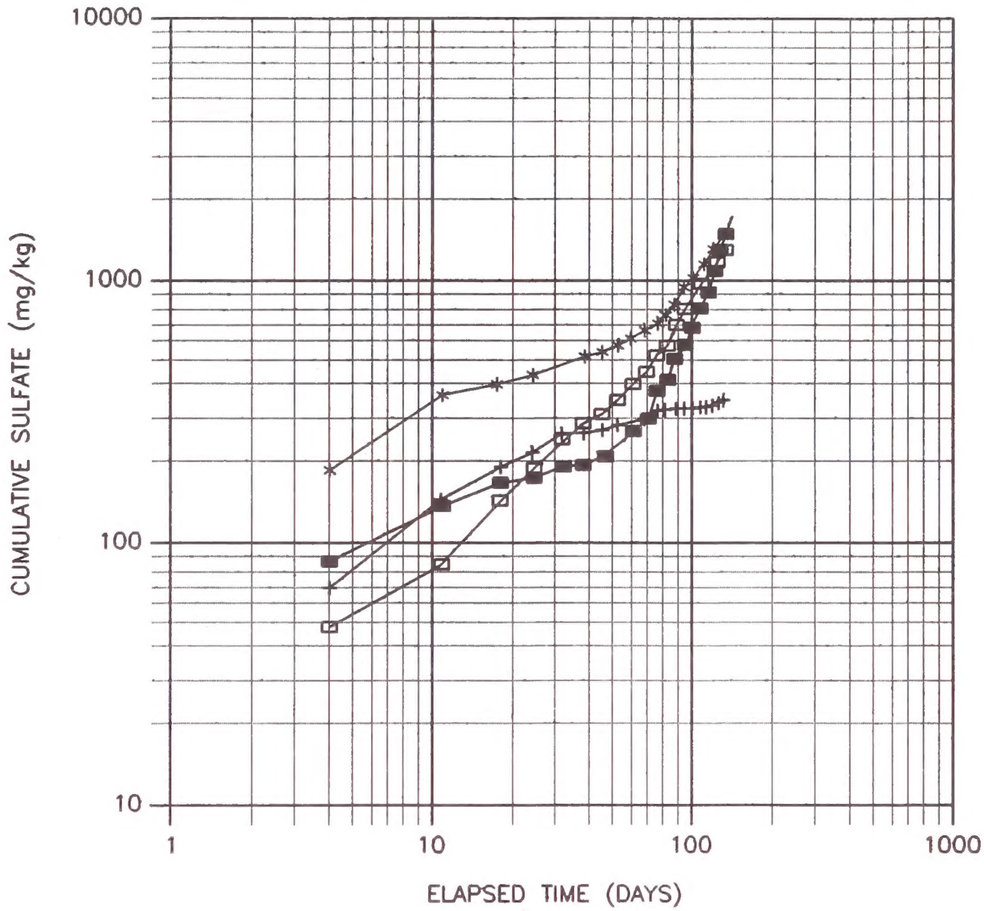
LS CAP/ NEUTRAL BASE

ZOR-WR02

SOURCE: ZORTMAN EXTENSION PROJECT - GEOCHEMICAL KINETIC TESTING OF WASTE ROCK

ZORTMAN WASTE ROCK CAP/BASE LAYER COMPARISON

FIG. 3.2-2a



ALKALINITY RELEASE FROM HUMIDITY CELLS SIMULATING SELECTED ALDER GULCH WASTE ROCK CAPPING AND BASE LAYER ALTERNATIVES

LEGEND

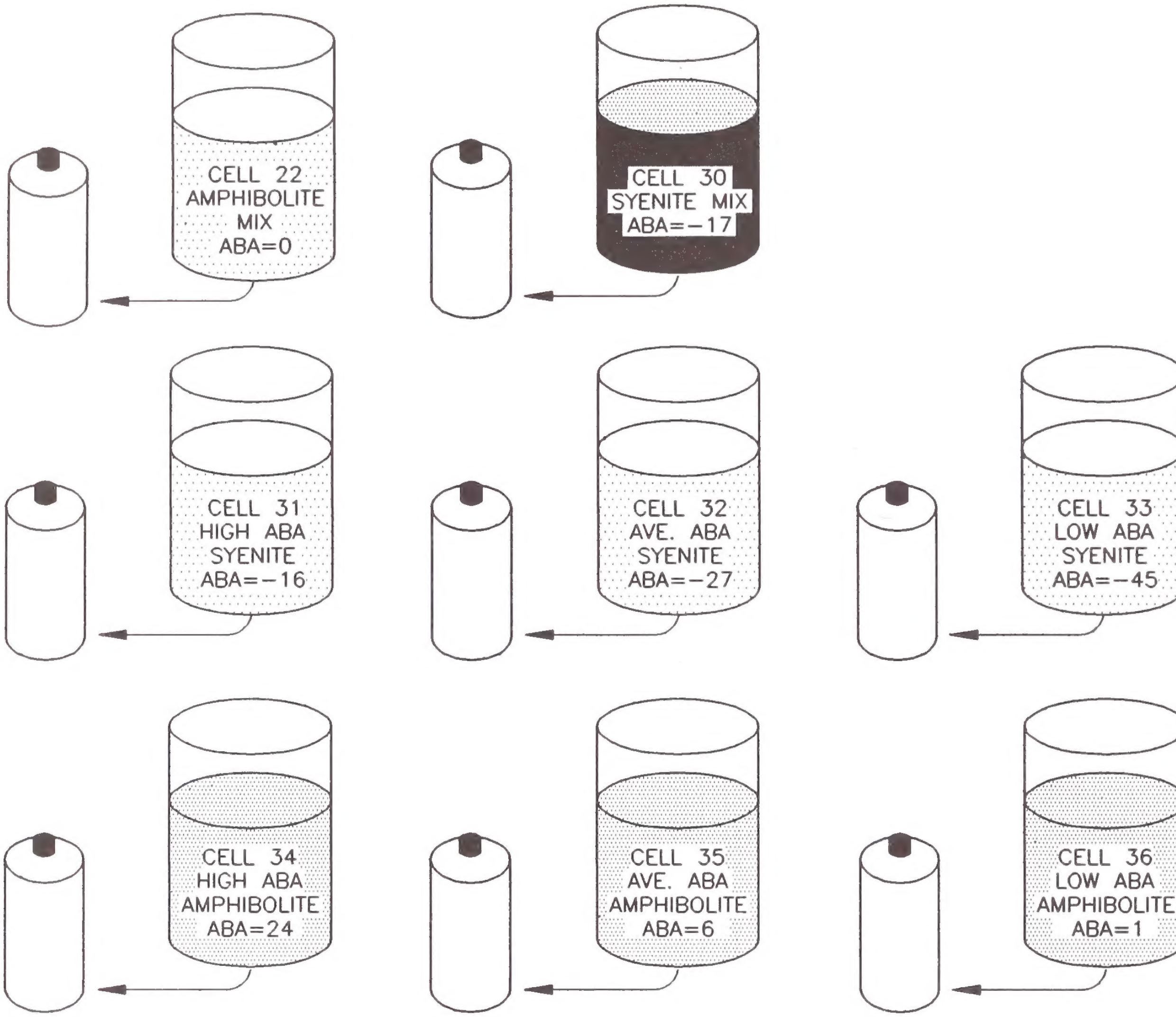
- NO CAP
- NEUTRAL CAP/LS BASE
- LS CAP/ LS BASE
- LS CAP/ NEUTRAL BASE

SOURCE: ZORTMAN EXTENSION PROJECT – GEOCHEMICAL KINETIC TESTING OF WASTE ROCK

ZORTMAN WASTE ROCK CAP/BASE LAYER COMPARISON

ZOR-WR01

FIG. 3.2-2b



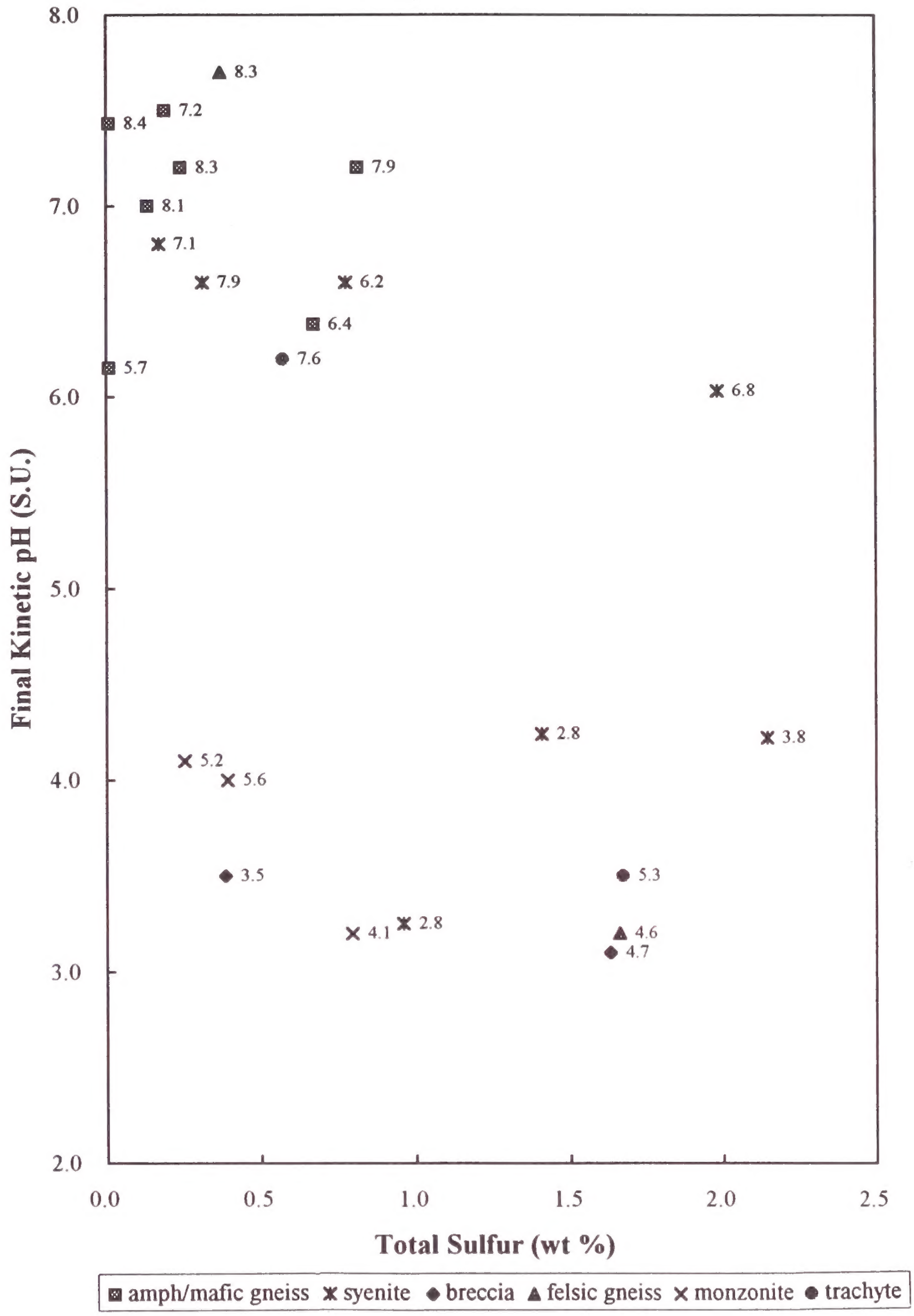
HUMIDITY CELL TESTS OF INDIVIDUAL SAMPLES
REPRESENTATIVE OF SPECIFIC DOMINANT LITHOLOGIES

SOURCE: ZORTMAN EXTENSION PROJECT – GEOCHEMICAL KINETIC TESTING OF WASTE ROCK

SHORT TERM
SINGLE HUMIDITY CELLS

ZOR-WR04

FIG. 3.2-3

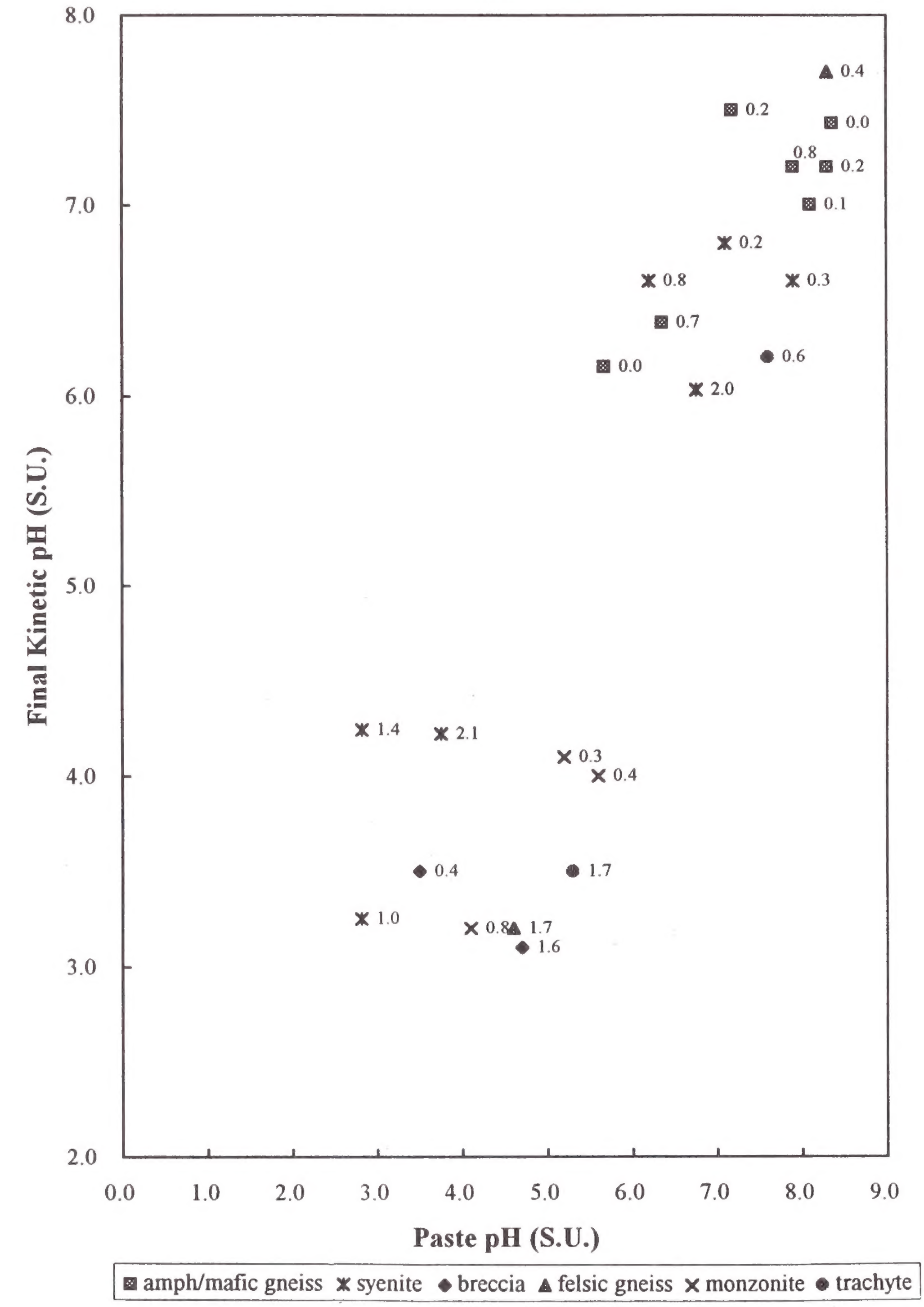


TOTAL SULFUR vs. FINAL KINETIC pH FOR ALL ROCK TYPES – PASTE pH LABEL. ALL AMPHIBOLITE/ MAFIC GNEISS AND ALL LOW SULFUR SYENITES PRODUCED LEACHATE WITH GREATER THAN 6.0 pH AFTER 45 WEEKS OF ACCELERATED WEATHERING.

FINAL KINETIC pH vs. TOTAL SULFUR FOR ZORTMAN WASTE HUMIDITY CELLS

ZOR-WR08

FIG. 3.2-4

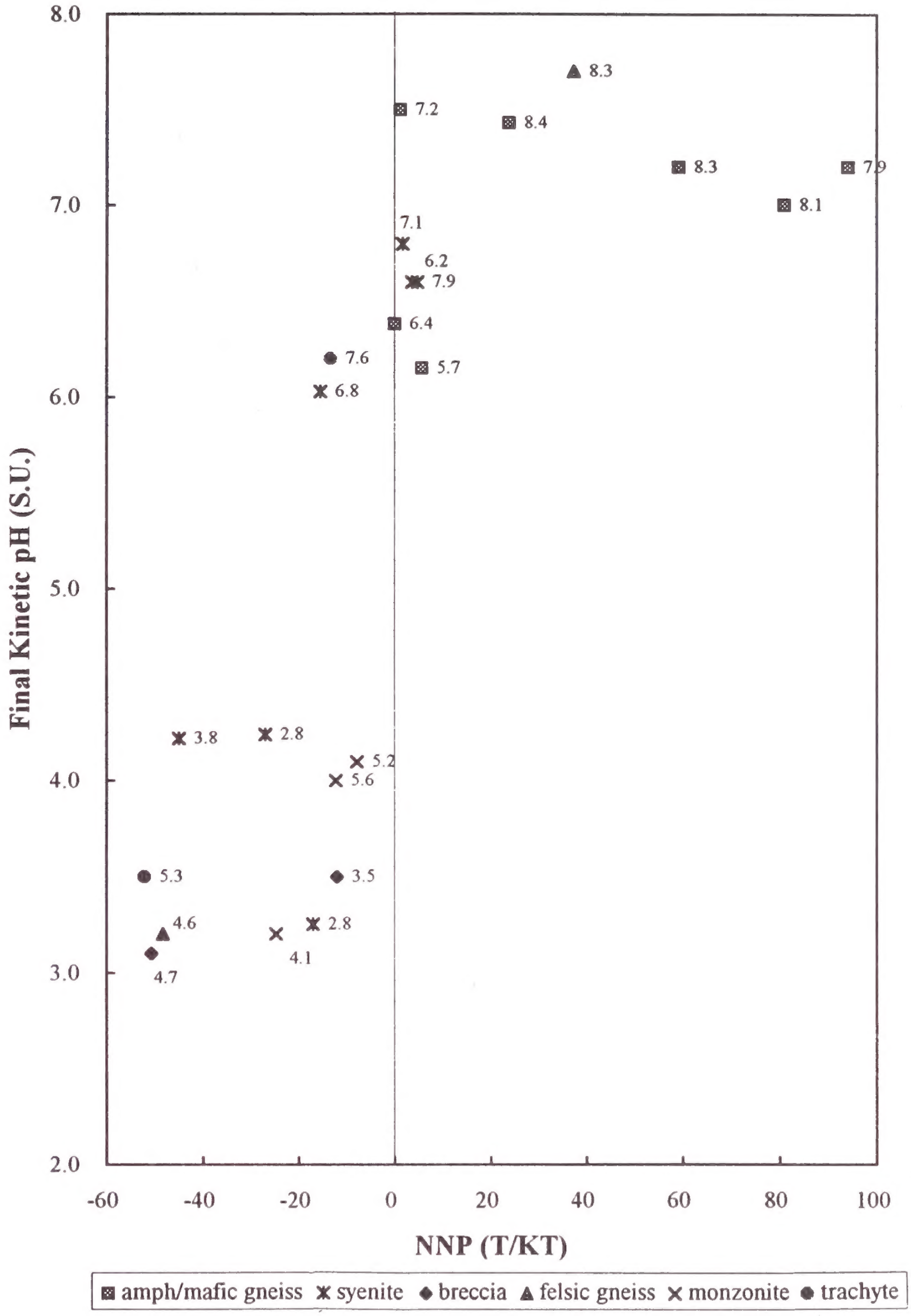


PASTE pH vs. FINAL KINETIC pH FOR ALL ROCK TYPES – TOTAL SULFUR (WT %) LABEL. ALL CELLS WITH PASTE pHs OF 6 OR GREATER PRODUCED LEACHATES WITH GREATER THAN 6 pH AFTER 45 WEEKS.

FINAL KINETIC pH vs. PASTE pH FOR ZORTMAN WASTE HUMIDITY CELLS

ZOR-WR09

FIG. 3.2-5

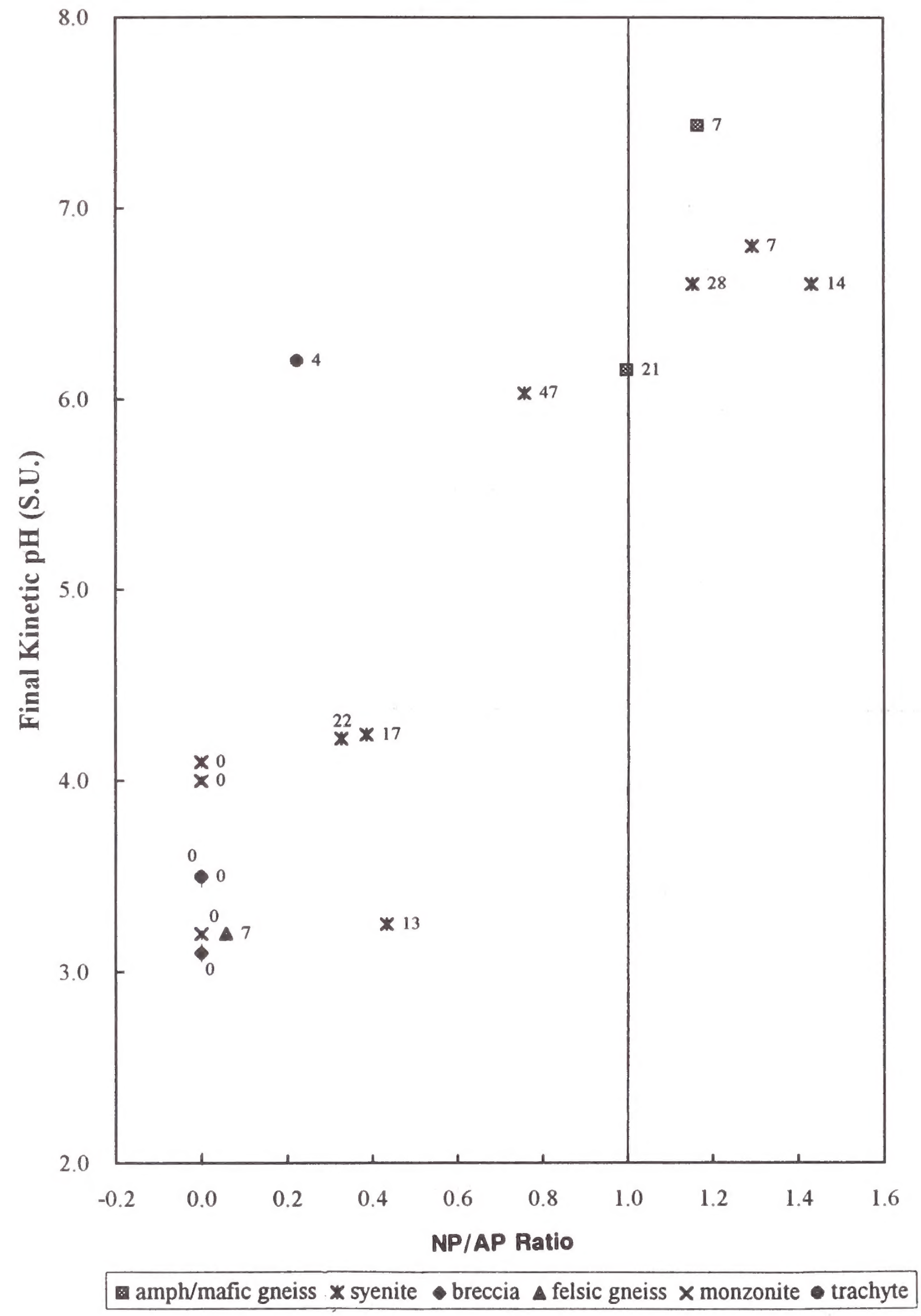


FINAL KINETIC pH vs. NNP FOR ALL ROCK TYPES – PASTE pH (S.U.) LABEL.
NO CELLS WITH AN NNP GREATER THAN 0 PRODUCED ACIDIC CONDITIONS.

FINAL pH vs. NNP
ZORTMAN WASTE CELLS
ALL ROCK TYPES

ZOR-WR07

FIG. 3.2-6

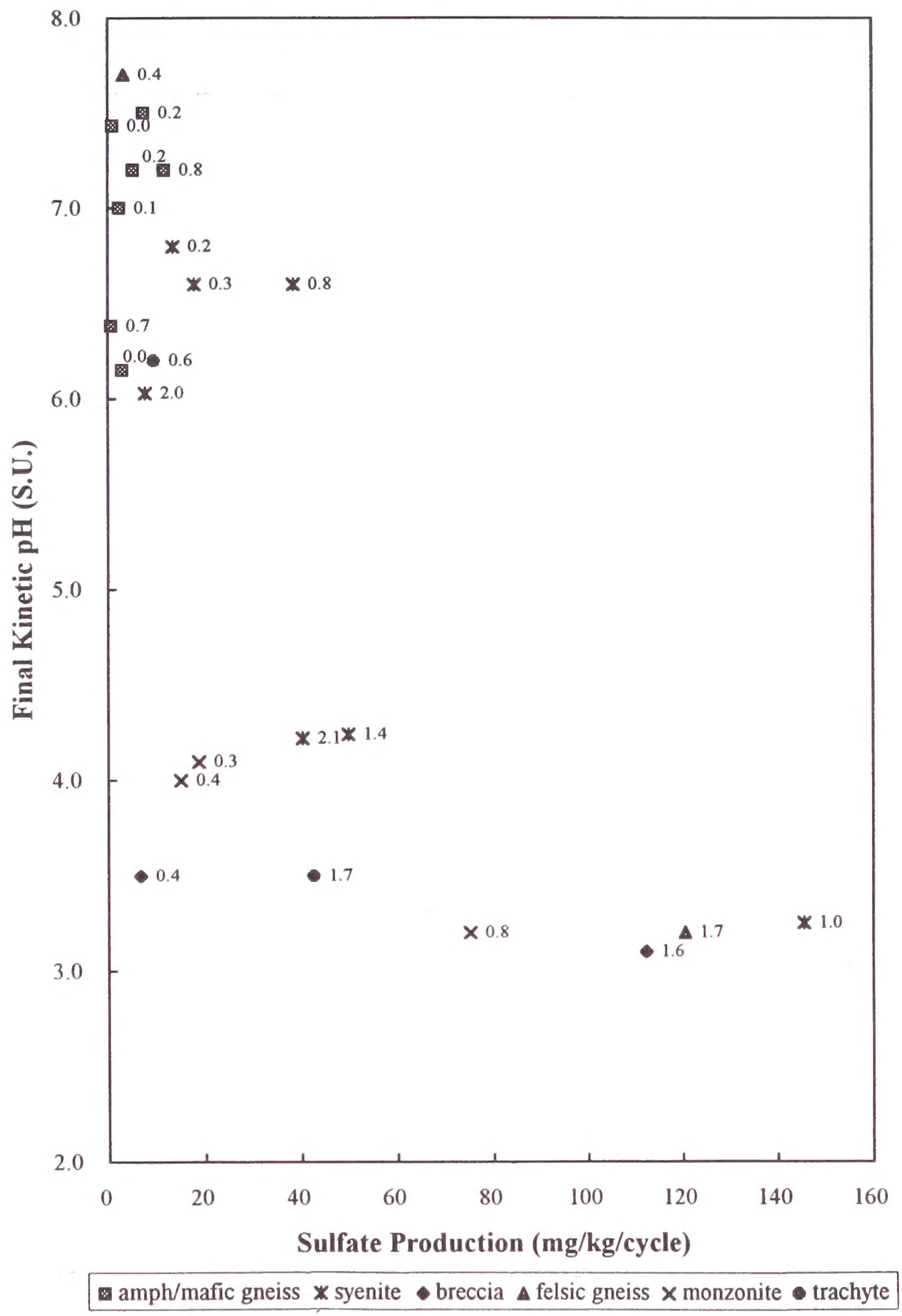


FINAL KINETIC pH vs. NP/AP FOR ALL ROCK TYPES – NP (T $CaCO_3$/T) LABEL. ROCK TYPES WITH NP=0 ALL PRODUCED ACIDIC CONDITIONS. CELLS WITH NP:AP OF GREATER THAN 1 DID NOT.

ZOR-WR05

FINAL KINETIC pH vs. NP/AP FOR ZORTMAN WASTE NP/AP<3

FIG. 3.2-7



FINAL KINETIC pH vs. SULFATE PRODUCTION FOR THE LATTER PORTION OF THE HUMIDITY CELL LEACHING – TOTAL SULFUR LABEL. NO CELLS WITH LOW SULFUR PRODUCED SUBSTANTIAL SULFATE.

FINAL pH vs. SULFATE PRODUCTION FOR LATTER PART OF TEST

ZOR-WR06

FIG. 3.2-8

total sulfur less than or equal to 0.2 percent,
paste pH of 6 or greater,
NNP greater than 0, and
NP/AP of 1 or greater

Comparison of Kinetic and Static Results

Archean Amphibolite/Mafic Gneiss and Paleozoic Sedimentary Rocks. Three 45-week humidity cells were conducted for sulfur content (0.2 to 0.8 percent) metamorphic rock to establish an upper sulfur limit for suitability. Results indicate that even at higher sulfur values, 0.8 percent or less, this rock category did not develop pHs less than 6.0 (Figure 3.2-4) or produce substantial sulfate or metals under conditions of the tests. This was probably due to the neutralizing potential of the metamorphic rock when compared to the igneous rocks. For five of the seven cells, acidity was markedly reduced or exhausted and the pH of the cell remained neutral in the latter half of the tests (Miller 1995). Therefore, this rock category would be suitable for construction, fill, and reclamation purposes if the following conditions were met: sulfur values of 0.8 wt % or less, NNP equal to or greater than 0, and a paste pH equal to or greater than 6.0.

Tertiary syenite porphyry. Syenite samples with a total sulfur content of less than 0.2 percent (Figure 3.2-4), a paste pH of 6.5 or greater (Figure 3.2-5), an NNP of 0 or greater (Figure 3.2-6), and an NP:AP of equal to or greater than 1 (Figure 3.2-7) did not produce acidic leachate or substantial sulfate under the accelerated weathering conditions of the test. Likewise neither did they release high levels of metals. Therefore, the portion of this rock type, which meets all criteria, would be considered suitable as reclamation cover material.

Other Tertiary igneous and Archean metamorphic rock. The remaining rock types: quartzite, breccia, monzonite, trachyte and felsic gneiss would be mined in minor volumes. Kinetic testing was not done on the quartzite rock type due to its limited abundance. The breccia and monzonite had low paste pHs, 3.5 to 5.6, and no NP. Figure 3.2-7 shows that, when the sample had little or no NP, the cell would produce acid conditions and sulfate at some time during the test. The trachyte and felsic gneiss had higher paste pHs, 4.6 to 8.3, and low or no NP. These results indicate that it is necessary to evaluate NNP for waste rock to effectively segregate reactive rock. In summary, this rock category produced unfavorable or inconclusive results and, therefore, is probably not suitable for use as construction, fill, underdrain, or reclamation cover material.

Landusky

Geological comparison. Geological/paleoenvironmental comparisons between very similar deposits have been shown to be appropriate in lieu of more extensive baseline kinetic testing. While use of this comparative technique has mostly been directed toward coal mining, recent studies indicate (USFS/DEQ 1995) this technique also applies locally to very similar metal deposits with similar rock types and associated alteration. This method has been used in Montana for homogeneous metal deposits such as the stratabound copper-silver deposits located in northwestern Montana. Mineralogical and static data, as well as extensive site examination and characterization, are needed to confirm the appropriateness of using this technique.

After accessing the existing mineralogical and static data for both Landusky and Zortman, it was determined that the deposits and the associated rock types were very similar. Results indicate, that for each rock type, material from both minesites are very similar with respect to geology and mineralogy (Richardson 1973; Russell 1991a; Russell 1995), iron sulfide types and occurrences (Honea 1992), total sulfur, paste pH, NP, AP, and NNP (Miller 1995). On this basis, a geologic comparison method was used and only limited kinetic testing was conducted on the Landusky materials, due to the relative small volume of the total material proposed to be mined from the Landusky ore deposit.

Long-term kinetic testing. Three composited kinetic cells were conducted for Landusky waste material (0.13, 0.31, and 0.57 percent sulfur) taken from the Little Ben pit. All had negative NNPs and paste pHs below 6.0. Two had initially low leachate pHs and the third developed a low pH, less than 5.5, after a period of 24 weeks. No cell met all criteria established for suitable waste given above, thus the testing was terminated. Therefore, the same criteria developed for the Zortman mine would apply for the additional waste to be generated by the Landusky expansion.

Continued Long-term Kinetic Testing

A series of additional humidity cell tests is currently underway and is being used more to measure the reproducibility of the test method rather than the reactivity of the material tested. However, results will be used to further corroborate the reactivity of the major rock types, especially the igneous rocks with a relatively low sulfur fraction.

3.2.2.7 Field Identification of NAG Waste

ZMI proposes to define NAG waste, blue waste, as rock having a total sulfur content less than 0.2 percent (see Section 2.8.1). Kinetic data discussed in the previous section indicate that the use of this single criterion is not sufficient to exclude reactive material, especially when considering certain igneous rock types.

In the 1994 Supplemental EA Decision Record for Landusky, the BLM and the DEQ identified more stringent criteria for defining NAG waste, partially due to the lack of long-term kinetic data. These criteria are:

- ANP three times greater than the acidification potential (NP > 3 AP)
- NNP greater than +20.

These criteria were implemented and are currently in use. From interpretation of the entire geochemical testing data set, it appears that ZMI's definition of non acid generating waste is too general and the agencies' previous definition of NAG waste is too restrictive..

Knowing the rock type, degree of alteration, sulfur content, NP, and the paste pH would allow efficient, effective waste segregation at both minesites. Using the results discussed, the following procedures would result in better sorting:

1. Every bench level should be mapped to document major rock types and alteration assemblages.
2. No monzonite, trachyte, breccia, felsic gneiss, or quartzite should be used as construction, fill, underdrain, or reclamation material due to their lack of neutralizing potential and their reactivity even at very low total sulfur values. Syenite porphyry waste (not meeting the criteria listed below) should not be used as underdrain or construction material or as fill in a drainage.
3. For each bench, when in waste rock, every third blasthole should be sampled and tested for total sulfur and paste pH.
4. When the site geologist determines, based on visual examination, that mining will occur in potentially suitable reclamation cover material, every blasthole should be tested for total sulfur, paste pH, and NP. Within a discrete mineable block (25 feet x 25 feet) the following criteria should be met to establish suitable reclamation material.
5. For syenite to be used as suitable reclamation material, the cutoff criteria would be less than or equal to 0.2 percent total sulfur, a paste pH of 6.5 or greater, <u>and</u> an NNP of 0 T $CaCO_3$/kT or greater. This requires an NP:AP ratio of 1 or greater.
6. Amphibolite, mafic gneiss, and shale, with a total sulfur content equal to or less than 0.8 percent and a paste pH of 6.0 or greater should be considered suitable for construction, fill, and reclamation purposes.
7. Documentation should be made of the rock type, alteration, total sulfur content, paste pH, NP and NP:AP ratio for all blastholes sampled. New data would be merged with the existing data set for continued evaluation during the mine life.

3.2.2.8 Unmineralized Geologic Materials

Clay Pits

Natural clay would be mined from local clay pits for construction of waste rock caps and waste and leach pad liner layers. Clays for the Landusky Mine would come from the Williams Pit, and are from either the Warm Springs Creek or Mowry Formations. Clays for the Zortman Mine could be mined from the Seaford pit and represent the Bearpaw Formation. These clays contain bentonite, and may contain significant concentrations of trace metals and relatively elevated total sulfur concentrations. Table 3.2-9 shows negative NNPs for all of the clay samples. However, it is unlikely that they would yield acid, since following compaction, they would have very low permeabilities. Also, given the nature of these sediments, it is likely that much of the total sulfur reported is actually present as sulfate and not sulfide.

Limestone Quarries

Under the Company Proposed Action, limestone for the Zortman Mine would be mined from the LS-1 quarry or the LS-2 site, and for the Landusky Mine from a quarry in the King Creek drainage or in Montana Gulch. Alternatives 3 and 7 would require the use of limestone from the LS-2 site for the Zortman Mine and the Montana Gulch site for the Landusky Mine. These limestones have been tested to have the following NNP ranges:

TABLE 3.2-9
CLAY PIT MATERIALS
ABA CHARACTERISTICS

	Paste pH	Pyritic Sulfur (%)	AP	NP	NNP
			(All in T/kT)		
Seaford Clay Pit	5.9	0.94	29	4.0	-25
Seaford Clay Pit	5.4	0.6	17	1.0	-16
Seaford Clay Pit	5.0	0.5	15	0	-16
Williams Clay Pit	3.2	2.7	85	0	-85
Williams Clay Pit	6.9	0.6	19	5	-14
Williams Clay Pit	6.7	0.6	20	13	-7
Williams Clay Pit	4.2	0.8	26	0	-31

	NNP values, range
Bighorn dolomite/mudstone	508 to 977
Jefferson (?) mudstone	976
Maywood mudstone	958

The number of unmineralized samples is very limited for all of these lithologies - for the Jefferson and Maywood formations only one sample - thus conclusions about ABA properties are limited. However, the Bighorn, Jefferson and Maywood materials, especially where limey, would have considerable neutralization potential.

Other Unmineralized Lithologies

Much of the unmineralized amphibolite and Emerson shale has low acid generation potential and can supply considerable neutralization if used as remediation material. The average NNP for Landusky amphibolite waste in Table 3.2-7a was 48.9, and for Emerson shale waste was 138.5 T/kT. However, additional ZMI exploration and development data show unmineralized amphibolite NNPs up to 86.9 T/kT and those for shales up to 678.8 T/kT. Research by Kwong (1993) indicates that the minerals composing amphibolites are likely to weather more slowly than common carbonates and would thereby provide a source of neutralizing capacity over the long term.

Foundation Materials

Several alternatives involve construction of a leach pad on Goslin Flats. This facility would be placed on foundation materials that are bentonitic clays of the Thermopolis shale. These shales are thick and generally impermeable. Some interbeds in the Thermopolis are calcareous and would provide buffering capacity, but are unlikely to react with any possible spent ore leachates because of the low permeability of the shale. The natural groundwater in these shales is generally of poor quality, i.e., high TDS and high sulfate concentrations.

3.2.2.9 Geochemical Findings

1. ARD is currently being generated from pit walls and floors, leach pads and pad foundations (91 leach pad), and waste rock piles at the Zortman and Landusky mines.

2. The groundwater in the Thermopolis shale at Goslin Flats has naturally high TDS, alkalinity, and sulfate. However, the leach pad and foundation is unlikely to be a source of acid due to its fine-grained nature and relative impermeability.

3. Clays to be used in construction of caps and liners have relatively low NNPs, but when compacted would have very low permeabilities. Thus the clays are unlikely to be a significant source of acid. Older clay liners that have recently been excavated at Landusky show little geochemical alteration.

4. Ore produced as a result of the Zortman and Landusky mine expansions would have acid producing potential (Schafer 1994). Leachates from spent ores would initially have alkaline pH's, relatively high TDS concentrations, and high concentrations of elements mobile at alkaline pHs such as arsenic, selenium and molybdenum. However, as remnant sulfides react, subsequent leachates would become acidic and contaminated with dissolved metals (See Section 4.2.1.3).

5. Ore from the Pony Gulch deposit, due to its very high NNP, could be used to mitigate leach pad effluent if placed at the bottom of the heap or if mixed with the lower lifts of Zortman ore. However, this deposit only is a reasonably foreseeable development and would not be developed sufficiently early in the Zortman Mine expansion for the ore to be placed in lower lifts of the leach pad.

6. For waste rock at both mines, there is a direct relationship between percent sulfur and NNP. Almost all sulfur is reactive and excluding the limestone, amphibolite, shale and dolomite, the waste rock has very little neutralizing potential. For both minesites, waste samples having negative NNPs should be considered potentially acid generating. Therefore, use of total sulfur and NNP as parameters for segregating waste would be effective.

7. A correlation between NP:AP and the final humidity cell leachate pH exists. The correlation allows using an NP:AP of 1 or greater as a cut-off for suitable waste.

8. Where the paste pH was 6.0 or above, acidic pHs in humidity cell leachates were not produced. Samples with a paste pH less than 6.0 identified low sulfur rock types which had already gone acid or contained stored oxidation products. Therefore, use of paste pH as a parameter for segregating waste would be appropriate.

9. All low to medium sulfur, 0.8 weight percent or less, amphibolite appears to be non-acid forming and could be used for construction, fill or reclamation purposes. Results after two years of kinetic testing still confirm it's non-acid generating character.

10. Syenite waste rock containing less than or equal to 0.2 percent sulfur and NNP of 0 T/kT or greater, does not generate acid in sufficient quantities to affect revegetation, but could affect water quality if this waste is placed where contact with surface water is likely to occur.

11. Breccia and monzonite rock types, currently designated as "blue waste" by ZMI (see Section 2), may generate acid or contain oxidation products sufficient to generate low pH conditions and therefore are not considered suitable for any construction, fill, underdrain or reclamation purposes.

12. For other rock types: trachyte, quartzite and felsic gneiss, static data indicated that these rock types did have the potential to generate net acidity, however kinetic data was inconclusive. Therefore these rock types have been excluded from use as construction, fill, underdrain, or reclamation purposes.

13. Should an insufficient quantity of suitable waste rock exist, unmineralized limestone, dolomite, and amphibolite with high NNPs would be available for construction, reclamation, or remediation activities in sufficient quantity to provide for completion of any alternative.

14. Underdrains and unlined pond systems should be built with unmineralized limestone or dolomite mined from areas not associated with the ore bodies.

3.2.3 Surface Water

Typically, drainages in the immediate vicinity of the Zortman/Landusky mining operations are ephemeral (flow for only a short time on occasion usually during snowmelt and storms) in the extreme upper reaches, then become intermittent (with more occasional flow, but yet discontinuous) or perennial (flow continuously) as a result of springs in the middle reaches and then again become ephemeral as they get further away from the range.

3.2.3.1 <u>Streams and Tributaries - Zortman</u>

The major streams and tributaries in the Zortman mining area are shown on Exhibit 1 (in EIS map pocket). Ruby Creek is the major drainage in the Zortman Mine area, flowing south approximately 25 miles to the Missouri River. Within the Ruby Creek drainage, several tributaries drain existing mining operations or proposed mine developments. These tributaries are:

- Alder Gulch
- Ruby Gulch
- Goslin Gulch

Tributaries to Alder Gulch consist of:

- Carter Gulch
- Alder Spur
- Pony Gulch

Tributaries draining the northeastern side of the Zortman mining operation flowing towards the Milk river are:

- Lodgepole Creek
- Beaver Creek

Most facilities associated with the Zortman mine are located within the <u>Ruby Gulch</u> watershed. Existing mining facilities in the Ruby Gulch drainage include the largest portion of the Zortman pits, the 89 leach pad, portions of the 1979-1982, and the 85-86 leach pads, and buttress. Ruby Gulch is also the location of historical disturbance and deposition of historic mill tailing.

Above the town of Zortman, Ruby Gulch is intermittent, flowing in and out of the thick deposit of historic mine tailing that fills the valley bottom. Surface water seldom reaches the town of Zortman, except during large precipitation events, or snow melts. During the period from 1989 to 1994, flows measured at location Z-1, in upper Ruby Gulch, ranged from 13 gallons per minute (gpm) to approximately 670 gpm. Flows measured at Z-15, near the central segment of Ruby Gulch, ranged from 0 to 250 gpm during the same years. High flows during unusually large precipitation/runoff events in the spring and summer, transport large amounts of coarse tailing material along Ruby Gulch, through the town of Zortman, and into Ruby Creek.

As previously noted, Carter Gulch, Alder Spur and Pony Gulch are tributaries to <u>Alder Gulch</u>. These tributaries contain several mining related facilities and would contain the Alder Gulch leach pad under Alternative 5. Alder Gulch also receives some minor drainage from a few historic adits. The uppermost reaches of the main channel of Alder Gulch are ephemeral; the drainage then becomes intermittent flowing only seasonally, or in response to major precipitation events or snow melts. The steep-sided channel consists of sedimentary material ranging in size from fine sand to boulders which have

been previously disturbed by placer mining. Surface water flow gradually infiltrates into alluvium as it moves downstream, and as a result Alder Gulch is typically dry once reaching its confluence with Pony Gulch. Runoff from significant rainfall events, such as that which occurred during 1986, 1988, and 1993, may transport large amounts of very coarse material down the lower portions of Alder Gulch.

Carter Gulch currently drains the existing Alder Gulch waste rock dump and would be almost entirely filled by the proposed Carter Gulch waste repository under Alternatives 4 and 5. The drainage is intermittent, incised and contains little sediment in the valley bottom.

Alder Spur receives drainage from 83 and 84 leach pad underdrains and portions of the 1979-1982 pads and buttresses. Alder Spur is intermittent, steeply incised and contains little sedimentary material in the valley bottom.

The Pony Gulch drainage does not contain any Zortman mining related mining facilities but does drain an area of historic mining at the head of its drainage. Pony Gulch is generally intermittent, but contains a 1,000-foot spring-fed reach located about one-half mile upstream of the mouth of the stream. Flow in this reach is approximately 5 gpm.

Goslin Creek is a tributary of Ruby Creek located between Whitcomb Butte and Saddle Butte. Goslin Creek joins Ruby Creek approximately three miles southeast of the town of Zortman. No mine workings or facilities are presently located in the Goslin Flats drainage area. Under some Alternatives, a conveyor system would extend from the mine pit area across Alder Gulch to Goslin Flats, and a heap leach pad would be constructed in Goslin Flats (shown in Exhibit 1). Channels in the upper portions of Goslin Creek are steep-sided and ephemeral becoming well vegetated and poorly defined in the lower sections. At least three alluvial, spring-fed stock ponds have been constructed in the lower channel. These stock ponds are jurisdictional wetlands, and an individual Section 404(b) permit is required for filling the ponds and leach pad construction. Outflow from these ponds produces small surface flows of approximately 5 to 10 gpm for short reaches, in channels which are otherwise typically dry.

The Lodgepole Creek watershed is the major drainage of the northern slopes of the Zortman mining area flowing north toward the Milk River. Glory Hole Creek, a tributary channel to upper Lodgepole Creek, contains mine spoils and some open pit disturbance in its headwaters. The drainage area diverted is estimated at 26 acres, approximately 0.6 percent of the total Lodgepole Creek drainage area that is upstream of the Fort Belknap Indian Reservation. Flow in the upper portion of the Lodgepole Creek is intermittent. Glory Hole Creek, draining the northern portion of current Zortman Mine operations is also intermittent in flow. At the confluence of Lodgepole Creek and Glory Hole Creek, a spring area provides perennial flow to Lodgepole Creek. The volume of flow in Lodgepole Creek generally increases as the stream approaches the Fort Belknap Indian Reservation, deriving additional volume from numerous tributaries upgradient of the Reservation boundary.

Similar to Lodgepole Creek, Beaver Creek is a major drainage for the northern and eastern aspects of the Little Rocky Mountains. Some historic hard rock mining occurred in the Beaver Creek drainage, but no present day or proposed mining activity is associated with this drainage. Flow is intermittent in the uppermost reaches, with discharge from several upland channel springs varying seasonally. The channel becomes perennial (runs throughout the year) approximately one mile downstream in a reach containing numerous beaver dams, which store significant quantities of water. Flow in Beaver Creek at the Reservation boundary is perennial.

3.2.3.2 Streams and Tributaries - Landusky

The major streams and tributaries in the Landusky mining area are shown on Exhibit 2 (in EIS map pocket). The southern portion of the Landusky mining area is drained entirely by Rock Creek and its tributaries. Major tributaries to the upper Rock Creek include:

- Sullivan Creek
- Mill Gulch
- Montana Gulch

The northern portion of the Landusky mining area is drained by Little Peoples Creek. Tributaries to Little Peoples Creek are:

- South Bighorn Creek
- King Creek

Swift Gulch is a tributary to South Bighorn Creek.

The upper portion of Sullivan Creek is ephemeral, with a narrow, steep channel composed of gravels and

cobbles. The major mining related facility located in this drainage is the 91 (Sullivan Park) heap leach pad.

The Mill Gulch drainage area currently contains the 87 (Mill Gulch) leach pad, the Mill Gulch waste dump, as well as the Landusky processing facility located at the head of a side drainage. The expanded 87/91 leach pad could be partially located in Mill Gulch and Sullivan Creek watersheds. Mill Gulch is an ephemeral stream in its upper and lower reaches, but has a middle segment that is intermittent. An alluvial spring located in this middle segment, flows at approximately five to ten gallons per minute for most of the year and causes Mill Gulch to flow for about 1,000 feet before infiltrating into the creek bed gravels. Mill Gulch is steep for most of its length, attaining a relatively flat gradient at its confluence with Rock Creek at Landusky. The channel is typically narrow, with a bed consisting of gravels, cobble, boulders, and occasional bedrock.

Facilities located within the Montana Gulch drainage include the 83, 84 and 85/86 leach pads, the Montana Gulch Waste Rock Dump, and the Gold Bug Pit/Waste Repository. Montana Gulch historically was an ephemeral, steep drainage in its upper reaches. The current flow from beneath the Montana Gulch waste rock dump is ongoing and the upper portion of the drainage is perennial. The streambed in the middle and lower portions of Montana Gulch varies from bedrock to fine sandy sediments. The Gold Bug adit, while essentially a groundwater source contributes a relatively constant flow of about 337 - 449 gpm and contributes the majority of the base flow in Montana Gulch and Rock Creek for a distance of approximately three miles (DSL 1979a).

Rock Creek has perennial flow in its upper segment but below its confluence with Mill Gulch, Rock Creek becomes intermittent. Base flow in Rock Creek is a combination of Gold Bug adit water (Montana Gulch), springs located on the Kolczak Ranch, and springs near the Little Rocky Mountains Camp.

King Creek joins South Bighorn Creek approximately 2 miles from the King Creek headwaters. South Bighorn flows for close to 3/4 of a mile before its confluence with the south fork of the Little Peoples Creek. Little Peoples Creek then exits the Little Rocky Mountains just southeast of the town of Hays.

Upstream of the South Bighorn Creek confluence with King Creek there is a tributary to South Bighorn Creek locally known as Swift Gulch which drains a portion of the northern side of the Landusky mining operation. Mine disturbances within this drainage are limited to a portion of the Queen Rose pit and some roads.

The King Creek original drainage basin contains the August pit, portions of the Gold Bug and Queen Rose Pits, and a portion of the Montana Gulch waste rock dump. King Creek's upper segment is steep, ephemeral, and intersects a number of historic mining disturbances, including the August mine, waste dump, tailing and associated roads. During high flow periods, King Creek and its smaller tributaries have in the past actively eroded tailing within the drainage, creating a steep-sided and unstable creek channel easily eroded during subsequent high flows. ZMI removed an estimated 75 percent of the tailing derived from the historical mining activities in the early to mid 1980s. In 1993, ZMI removed the majority of the remaining tailing from the upper reaches of King Creek above the tailing dam in an effort to further reduce the amount of tailing washing downstream. An investigation (WESTECH 1978) showed that King Creek was flowing about 20 gallons per minute as it entered the Fort Belknap Indian Reservation, and that historic tailing were (at the time of the investigation) a significant part of the stream channel well into the Reservation.

3.2.4 Groundwater

Recharge to the groundwater system within the Little Rocky Mountains is derived from infiltration of runoff and precipitation on higher ground, and infiltration of channelized runoff to the range front deposits and alluvial systems around the margin of the higher ground. Therefore, the water table elevations within and surrounding the range broadly mimic the surface topography. Faulting and fracture systems which are both radial and tangential to the intrusive core control the outward flow of groundwater. Secondary permeability, resulting from solution cavities and other karst features common to carbonate rocks, also control groundwater flow. Water which becomes recharge to the groundwater system moves slowly downslope through the intrusive rocks. Groundwater flow paths are complex and are controlled by the presence and alignment of open fractures.

Stratigraphy

A major aquifer of importance to this study surrounding the Little Rocky Mountains is the Madison Group. The Madison Group (also called the Madison Limestone where it is not divided) is composed of two formations in the study area (see Figures 3.1-1, 3.1-2). The lower is the Lodgepole Formation, and the upper is the Mission Canyon Formation. In the Little Rocky

Mountains, the Lodgepole Limestone is about 478 feet thick, and the Mission Canyon Limestone is 325 feet thick (Feltis 1983). The Mission Canyon Limestone forms great ridges at the outer rim of the Little Rocky Mountains, as well as several prominent ridges and buttes within the mountainous area and in the foothills (Feltis 1983).

Alluvium varies in thickness throughout the length of the gulches of the Little Rocky Mountains. For example, in Alder Gulch, alluvial material varies in thickness from 10 feet at its headwaters, to as deep as 50 feet below the confluence with Pony Gulch.

Bedrock is primarily fractured syenite porphyry near the head of the drainages. Cretaceous shales and siltstones occur once the drainage system enters flat prairie at the periphery of the Little Rocky Mountains (see Section 3.1).

Structure and Historic Mine Workings

Two main styles of high angle or steep faults exist in the Little Rocky Mountains. Normal faults which flank the Little Rocky Mountain uplift but tend to follow contacts between different rock units, and angle away from the uplift; and secondly radial faults in and around the margins of the uplift.

Near the Zortman Mine, structures generally trend north-northeast are steeply dipping and appear to be confined to the intrusive body. The north-northeast oriented shear zones include Ruby, Ross, and O.K. shear zones. Breccia dikes and veins are also present in many of the mine workings at Zortman; most notably within the O.K. and Ruby Pits.

The Zortman mining area is underlain by numerous underground openings and workings. Two haulage adits connect these workings to the ground surface, one daylighting north of the Ross Pit in the Lodgepole Creek drainage and the other to the southeast of the O.K. pit under the 85 pad in Ruby Gulch. These adits and workings are all above the static groundwater table and convey only transient water flow (Golder 1995).

The principal structural controls on groundwater flow in the syenite porphyry rock at the Landusky mine appear to be the northeast oriented shear zones, principally the Gold Bug, Suprise, Niseka and August shears, and the smaller sympathetic fracture systems in the direction of shearing (Water Management Consultants 1995). The shear zones have areas of greater fracture density which may result in enhanced hydraulic conductivity. If so, the fracture system may act as a conduit imparting a preferred southwesterly orientation for groundwater flow through the mine area.

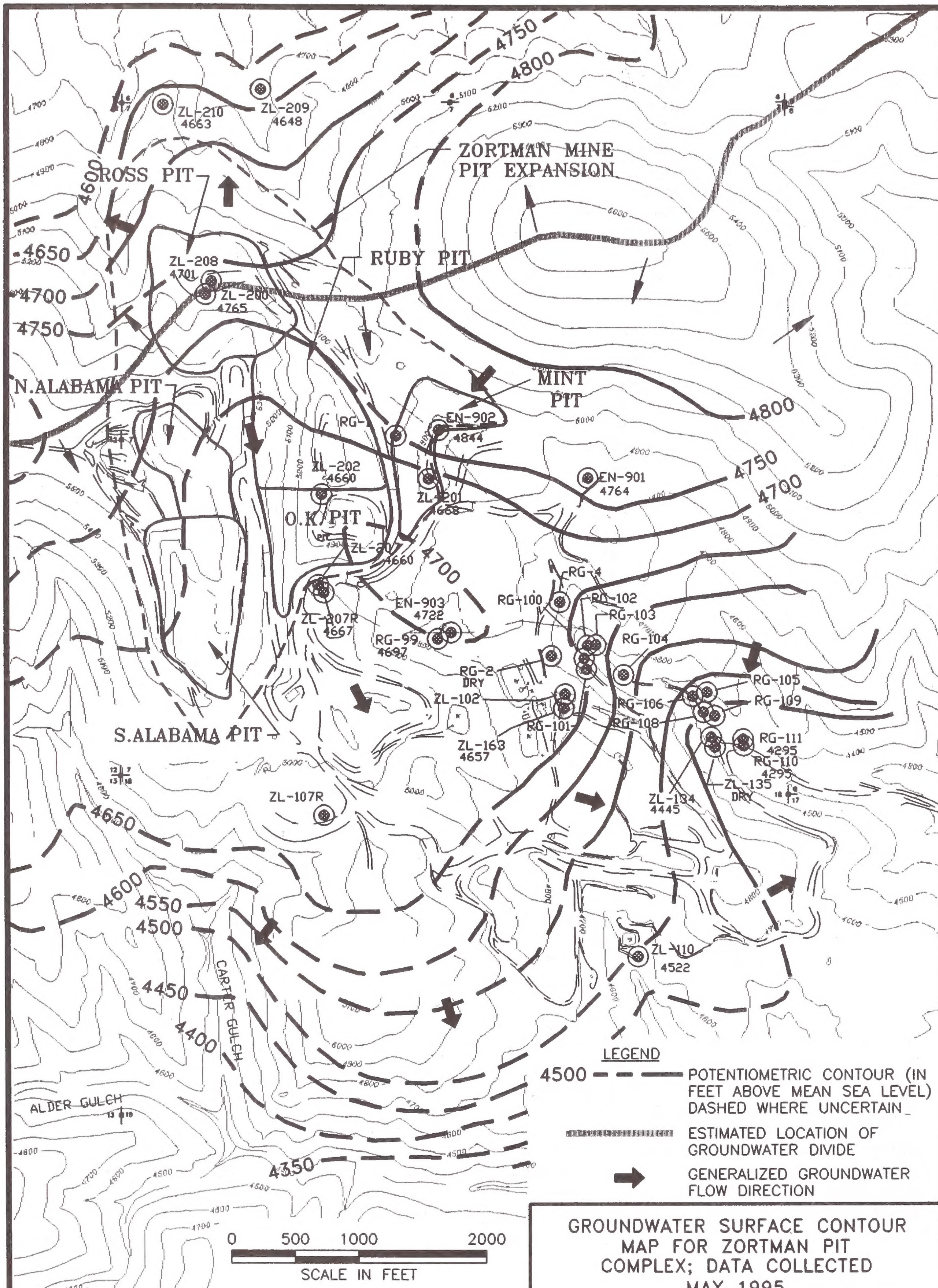
Alternatively, the underground historical mine workings may be the primary features draining groundwater from beneath the mine area. Historic workings underlying the Landusky Mine include:

- The August drain adit daylighting beneath the Montana Gulch waste rock dump, at the head of Montana Gulch at an elevation of 4,604 feet; the drain runs to the northeast for a known distance of about 1,500 feet and follows the August Shear Zone
- The Niseka workings, the portal of which is also at the head of the Montana Gulch, close to the portal of the August drain adit but at approximately 160 feet higher elevation
- The Gold Bug Adit, located about 1,700 feet to the southeast of the August drain adit, the Gold Bug Adit also trends to the northeast although the full extent of the Gold Bug workings is not fully known; the portal also occurs in the headwaters of Montana Gulch at an elevation of about 4,576 feet.

Groundwater Surface Pattern

Water level data are gathered by ZMI from all monitoring wells during sampling events; ZMI monitoring well locations are shown on Exhibits 1 and 2 (FEIS map pocket). ZMI monitoring wells located within the Little Rocky Mountains at or adjacent to the mine sites are predominantly located near to or at the base of drainages. This distribution makes the definition of a groundwater surface pattern difficult and potentially unreliable. However, given the steep topography it is expected that the groundwater potentiometric surface will generally reflect the surface topography with flow from topographic highs to valley lows. Deviations from this pattern are noted at higher elevations within the porphyry syenite, where the mine pits, numerous historical mine adits and shafts have intersected water bearing zones and highly fractured mineralized rock. The direction and rate of groundwater flow in the bedrock is also affected by faults, hydrothermal alteration, geologic contacts, and variabilities in porosity.

At the Zortman Mine, available water level data places a groundwater divide at the northern most extent of the open pit area (Figure 3.2-9); however, the location of this groundwater divide is subject to some debate due to the limited number of monitoring wells from which to contour the groundwater surface. Figure 3.2-9 illustrates contoured water level data collected in May 1995 at Zortman. Observations of groundwater seepage at the



GROUNDWATER SURFACE CONTOUR MAP FOR ZORTMAN PIT COMPLEX; DATA COLLECTED MAY 1995

ZORPOT

FIG. 3.2-9

head of Ruby Gulch and the available water level data within the pit complex suggest that most of the groundwater recharged in the pits flows southeasterly towards Ruby Gulch, possibly along fractured rock pathways resulting from faulting of the porphyry intrusive rock. The fact that the headwaters of Ruby Gulch were frequently intermittent prior to deepening the Zortman pits during 1985 illustrates how the pits effectively funnel infiltrated surface water runoff into Ruby Gulch. Surface water flow in upper Ruby Gulch since 1985 has typically been around 150 gpm (DEQ 1996). The correlation between water quality degradation in Ruby Gulch and the deepening of the Zortman pit complex also suggests the existence of a preferred groundwater flow path between the pits and Ruby Gulch. Some of the recharge to the groundwater system may also drain to the north. Due to the limited amount of monitoring points located to the north of the Zortman pit complex (two bedrock monitoring wells), it is not certain that no impacted groundwater is currently flowing to the north. However, there is no geochemical evidence, such as ARD contamination, suggesting a northward component of groundwater flow from the pit complex. Another component of groundwater flow is a deep, near-vertical recharge route into the porphyry bedrock and eventually into the sedimentary formations surrounding the Little Rocky Mountains.

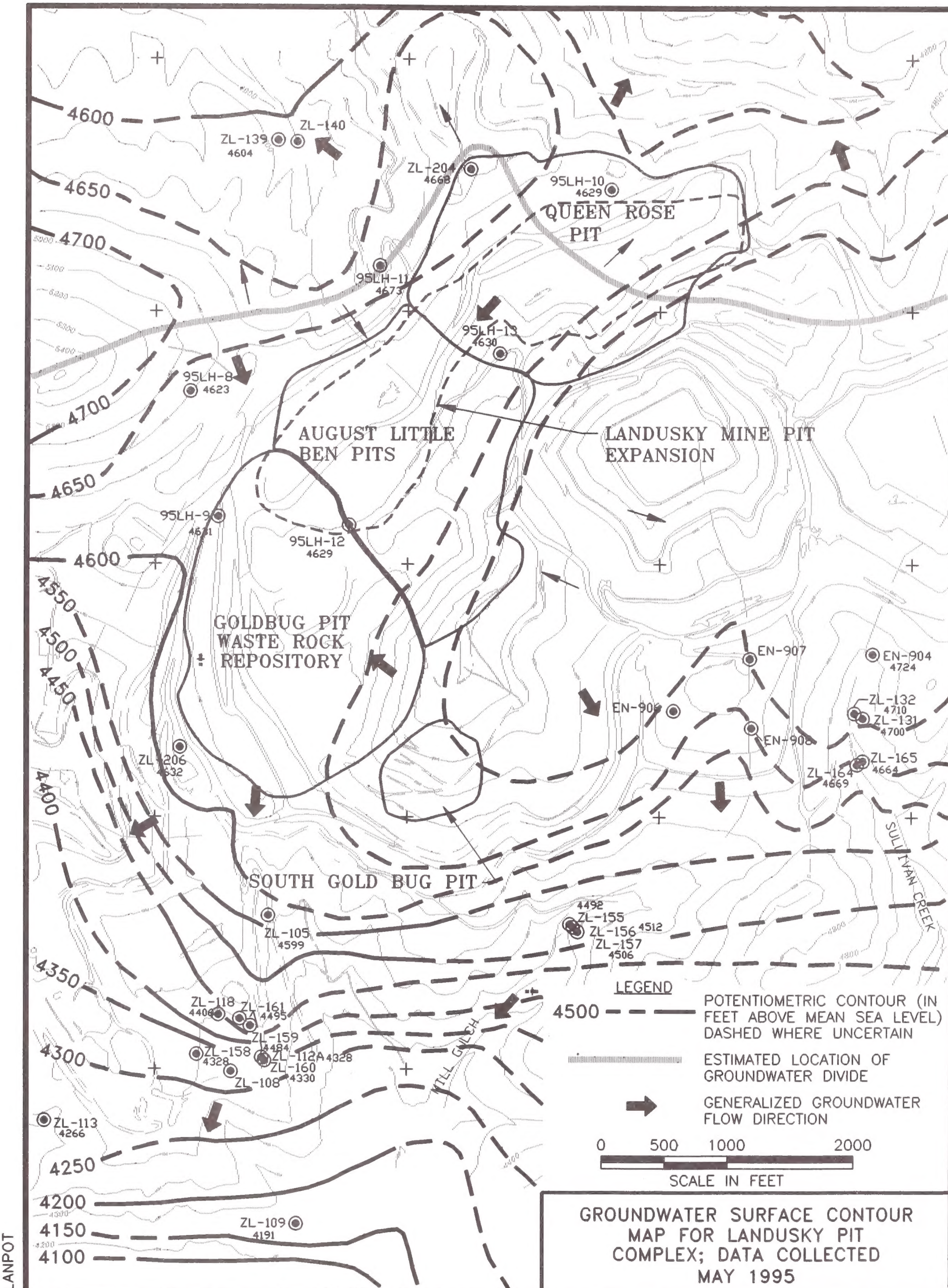
At Landusky, the exposure of historical mine workings in the pits, and large volumes and near constant flow of water from the Gold Bug Adit and August drain adit, suggests they must be having a substantial effect on the water table in the vicinity of the Gold Bug Pit and August Pits.

A recent study of the groundwater conditions associated with the proposed expansion of the August Pit indicates that northeast oriented shear zones are the principal features controlling groundwater flow in that area. Further to the southwest, it appears the August Drain Adit is providing an efficient drainage outlet for the intrusive rocks. Figure 3.2-10 illustrates contoured water level data collected during May 1995 at Landusky. The low water elevation recorded in test hole 95HL-008 (4,625 feet) may indicate the natural drainage of the ore body is also occurring to the southwest towards Montana Gulch because of the hydraulic connection along the shear zones. In addition, the low water level elevation measured in 95LH-010 (4,633 feet) may indicate that water in the Suprise Shear Zone is draining naturally to the northeast, towards Peoples Creek. It is possible that the spring L-20 may represent a natural discharge point for groundwater in the Suprise Shear Zone (Water Management Consultants 1995). In general, groundwater elevations in the vicinity of the August Pit range from about 4,625 feet to 6,634 feet (approximately 190 feet below the current ground surface). A zone of higher (perched) groundwater elevations has been encountered in the Narrows Fault Zone. Water levels in this area are approximately 4,770 feet, some 140 to 150 feet above the water elevation in the main shear zone. Springs L-5 on King Creek could be the result of drainage from this perched groundwater discovered within the vicinity of the August Pit (Water Management Consultants 1995).

On the southern side of the Landusky Mine, some of the seeps in the headwaters of Montana Gulch are consistent with groundwater elevations in the intrusive rocks along the line of the August Shear Zone. In Mill Gulch, springs L-8 occurs at an elevation of 4,450 feet, this spring is likely related to groundwater flow in the intrusive rocks along the Gold Bug shear zone (Water Management Consultants 1995).

Many springs occur along the flanks of the Little Rocky Mountains. Many of the springs are recharged through precipitation and infiltration into exposed limestones as evidenced by the quick reaction of spring flow to the precipitation events in the mountains (Feltis 1983). Data from oil well drill stem tests on the Fort Belknap Indian Reservations and wells installed as part of the USGS Water Resources Investigation 93-4193 show the potentiometric surface of the water in the Madison Group limestones and overlying formations to be near ground level and artesian in many cases. These artesian conditions reduce the potential for infiltration of surface water on a regional scale, i.e., outside the Little Rocky Mountains. However, it is uncertain if these artesian conditions contribute baseflow to the springs surrounding the Little Rocky Mountains.

Monitoring wells constructed in the alluvium and bedrock at the town of Zortman show the alluvium to be unsaturated and the limestone bedrock to have vertical downward gradients. These downward gradients increase the potential for surface water and alluvial groundwater to recharge the Madison limestone near the town of Zortman where the limestone is exposed or underlies alluvium. However, further downstream at Goslin Flats, the shale overlying the limestones limits the potential for any direct recharge to the limestone. The decrease in volume or absence of water observed in the streams and alluvium at downstream locations suggests a significant portion of the flow is currently intercepted by the limestone units where they are exposed in the streambed or directly underlie the alluvium.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ZL-140
ZL-204
4668
95LH-10
4629
QUEEN ROSE
PIT
95LH-11
4673
95LH-13
4630
95LH-8
4623
AUGUST LITTLE
BEN PITS
LANDUSKY MINE PIT
EXPANSION
95LH-9
4631
95LH-12
4629
GOLDBUG PIT
WASTE ROCK
REPOSITORY
EN-907
EN-904
4724
EN-906
ZL-132
4710
ZL-131
4700
EN-908
ZL-165
4664
ZL-164
4669
ZL-206
4632
SULLIVAN CREEK
SOUTH GOLD BUG PIT
4492
ZL-155
ZL-156
4512
ZL-157
4506
ZL-105
4599
ZL-118
4408
ZL-161
4495
ZL-159
4484
ZL-158
4328
ZL-112A
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ZL-160
4330
ZL-108
TILL GULCH
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LEGEND
4500 POTENTIOMETRIC CONTOUR (IN FEET ABOVE MEAN SEA LEVEL) DASHED WHERE UNCERTAIN
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GENERALIZED GROUNDWATER FLOW DIRECTION
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SCALE IN FEET
GROUNDWATER SURFACE CONTOUR MAP FOR LANDUSKY PIT COMPLEX; DATA COLLECTED MAY 1995
LANPOT

FIG. 3.2–10

In summary, key points concerning groundwater flow in the Zortman and Landusky study areas are:

- Downward hydraulic gradients exist in the upper levels of the Little Rocky Mountains, allowing infiltration and recharge directly into the permeable metamorphic and igneous rocks at higher altitudes in the Little Rocky Mountains.

- The Madison Group limestones exposed within the Little Rocky Mountains have received recharge by waters impacted by mining activities. This recharge is facilitated by downward vertical gradients in the rocks exposed in the streambeds.

- The overlying low permeability shales and the upward hydraulic gradients within the Madison Group Limestone reduce the potential for direct recharge once outside the Little Rocky Mountains.

- Springs flanking the Little Rocky Mountains are recharged by infiltration at higher elevations.

- The available water level data and significant volume of water discharging to the headwaters of Ruby Gulch suggests that the majority of the recharge to the Zortman Pit complex discharges to Ruby Gulch. It is unclear if any groundwater discharges to the north due to the limited number of monitoring wells and the uncertainty concerning the exact location of the groundwater divide.

- The Gold Bug and August Adits and associated northeast - southwest oriented shear zones have a significant effect on groundwater flow directions in the upper elevations of the Landusky mining area, effectively draining the overlying groundwater to a level well below the present bottom of the Landusky Pits and discharging it to the Montana Gulch drainage in the Landusky Pit complex.

- The position of the groundwater divide and the presence of elevated or perched groundwater in the vicinity of the August Pit suggests there is potential for groundwater to discharge to both Swift Gulch and King Creek.

3.2.5 Water Quality

3.2.5.1 Surface Water Quality

Data Sources

Surface water flow and quality data have been collected periodically by Hydrometrics and ZMI from monitoring sites in the mining area since 1979. This baseline monitoring effort has developed into a long-term sampling program at a number of sites with the objective of detecting long-term changes in the hydrological systems within and peripheral to the mining area. General surface water resources data are presented in the Zortman and Landusky Water Resources Annual Monitoring Reports (AMR) prepared for ZMI by Hydrometrics (ZMI 1982 through 1995). Additional flow and surface water quality data have been gathered periodically by the BLM, Montana DEQ, and USGS. Data was also collected prior to Zortman mining activity as part of the 1979 Zortman/Landusky EIS (Botz and Gartner 1978).

Surface water monitoring has developed into a network of approximately 63 stations, positioned throughout the length of drainages containing mining related activities and within several drainages currently not affected by mining. As of 1994, water resources monitoring for a suite of chemical analyses has been carried out on a quarterly basis with operational data (for "indicator" chemistry such as pH, SC, and cyanide) being gathered from selected wells on a weekly and in some cases a daily basis. As part of this EIS, all available monitoring data have been compiled and reviewed in order to assess baseline (pre-1979) and existing groundwater and surface water quality and surface water flow conditions in both current mining areas and proposed extension areas.

The surface water monitoring record allows a good general determination of what drainages have been significantly impacted by mining related activities. Operational monitoring (field analysis at selected locations on a weekly and in some cases, daily basis) effectively identifies periods of water quality degradation. However, the frequency of complete project area monitoring has typically been biannual in the past and has resulted in the lateral extent and/or significance of water quality degradation being unclear for some periods. During many surface water sampling rounds, surface water stations are often dry. If this happens repeatedly at a station, the monitoring record can be very limited. Also, the downstream extent of water quality degradation is unclear in some drainages due to a limited number of downstream monitoring stations. See Section 2.7.3.1 for a description of the agency proposed monitoring program for surface water and groundwater that would overcome many of these problems.

The following water quality parameters are recognized indicators of ARD and releases of gold processing

chemicals, and form the basis of the review of surface water and groundwater quality.

- pH - A low pH (<6.0) acidic water may be an indicator of ARD, while a high alkaline pH value (>8.5) may signify a release of process liquids from the operation facilities

- Metals - A number of metals are commonly mobilized (go into solution) upon contact with acidic fluids. These include Arsenic (As) which is soluble at a wide range of pHs, Iron (Fe) common at relatively high concentrations, Lead (Pb), Nickel (Ni), Zinc (Zn), Cadmium (Cd), Copper (Cu), and Aluminum (Al).

- Total dissolved solids (TDS) - The concentration of dissolved constituents in the water can increase exponentially as the solution pH decreases, so an increase in TDS over time may indicate the development of ARD

- Sulfates - Sulfate is a product of the oxidation of pyrite and other metal sulfides. An increase in sulfate concentration in surface or groundwater can signify the existence of acid rock drainage contamination even when the pH remains unchanged. The effect of metal sulfide oxidation on groundwater is sometimes more subtle than on surface waters, as the iron released may be precipitated or lost by cation exchange and the sulfate may be lost by reduction as water moves through the aquifer (Hem 1992).

- Specific conductivity (SC) - As with TDS, an increase in SC signifies an increase in the proportion of dissolved constituents.

- Cyanide - Cyanide solutions are used in the heap leach gold recovery process. Anomalous detections of cyanide or its nitrogen breakdown forms (nitrate, nitrite, ammonia) in surface and groundwater downgradient of a facility indicates a problem with the cyanide containment system. Note: Low levels (<0.1 mg/L) may be due to cross contamination between processing laboratory and environmental laboratory work i.e., a low cyanide detection often does not equate to a leak or spill.

- Nitrates and Nitrites - As well as being a breakdown product of cyanide, nitrate is present in most mined material due to the use of ANFO as a blasting agent. Nitrate can also be derived from fertilizers used during reclamation.

- TSS - An increase in TSS may represent erosion events or disturbances to land surfaces within the drainage.

Tables and graphics are used in this EIS to illustrate water quality changes over time and the variation in water quality within a particular drainage area. The major ion chemistry of surface waters from the Zortman and Landusky mining areas are summarized on Figures 3.2-11 and 3.2-12, respectively.

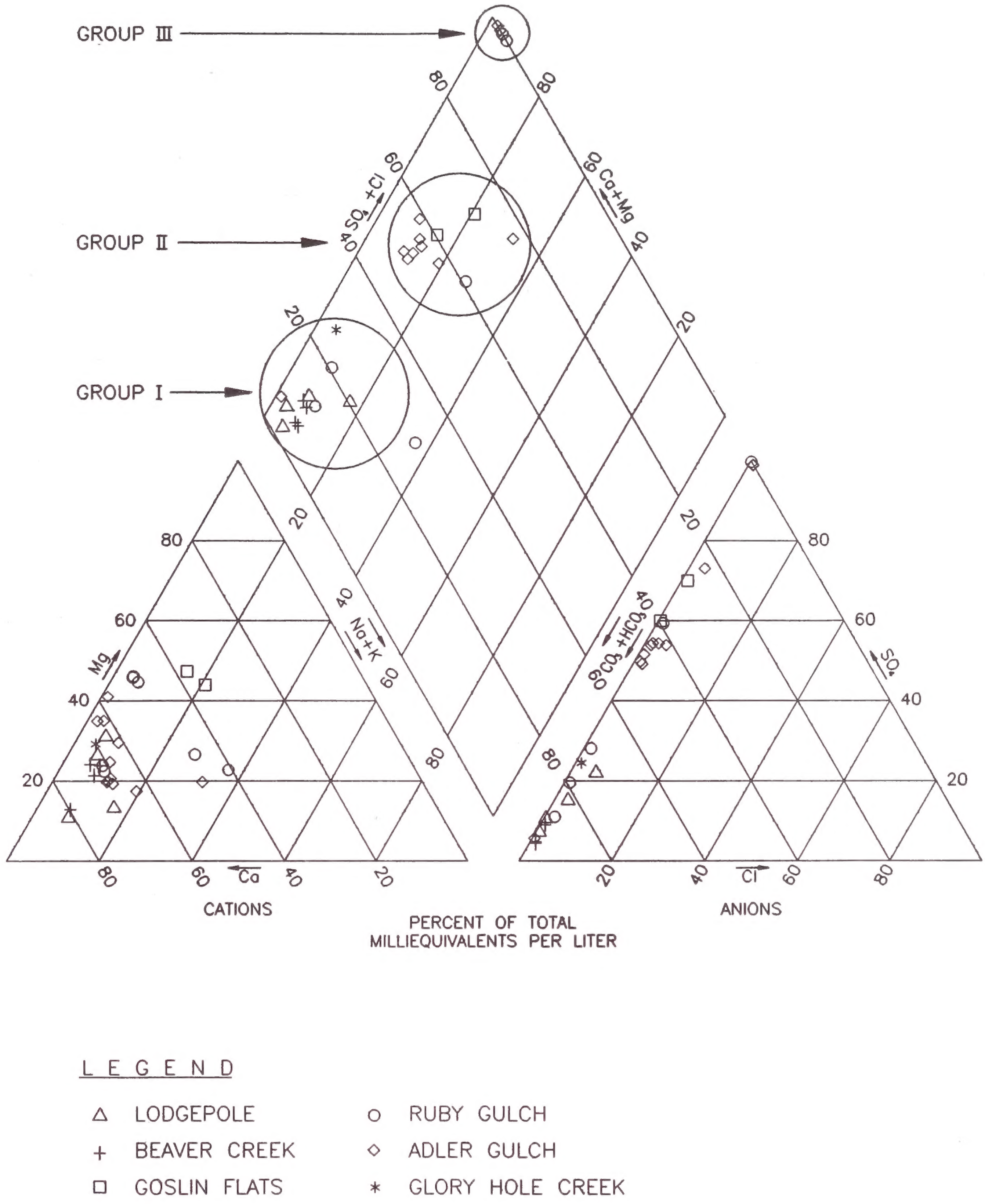
The surface waters from the Zortman mining area fall within three general groups depending on their percentage sulfate (Figure 3.2-11). Elevated sulfate is discussed above as a product of ARD. Surface waters plotting in group one include Lodgepole, Beaver and Glory Hole Creeks, as well as some samples from Ruby and Alder Gulches. These waters are of a calcium carbonate and represent baseline surface water chemistry for the Little Rocky Mountains with little or no signs of impacts from ARD. Group two includes waters from Ruby and Alder Gulches and Goslin Flats. Waters from Ruby and Alder Gulches have higher levels of sulfate than those in group one due to the impact from ARD. Goslin Flats has a naturally high sulfate content due to interaction with the mineral rich shale bedrock; these waters are of a general magnesium sulfate type. Finally, group three consists of highly impacted waters from Ruby and Alder Gulches, their chemistry being dominated by sulfate.

The Landusky surface water data, plotted on Figure 3.2-12, show the waters to also be of a calcium sulfate type. With the exception of King Creek, waters from Montana Gulch, Mill Gulch, Rock Creek and South Bighorn are spread along the sulfate axis depending on the degree of impact from ARD, the sulfate content decreasing with distance downstream due to dilution and attenuation of sulfate complexes.

The surface water quality of each drainage within the Little Rocky Mountains will be discussed in detail within the remainder of this chapter.

Baseline Surface Water Quality - Pre-1979

Table 3.2-10 summarizes all the available baseline "pre-1979" surface water data. Because mining activity has been ongoing since the early 1900s in the Little Rocky Mountains, water quality data gathered prior to Zortman mining activity is defined as "baseline" rather than "background" because the water chemistry may have already been impacted by the effects of mining activity. The record shows Montana Gulch, Rock Creek and King Creek at Landusky to have had the highest SC, TDS and sulfate concentrations. Although few metal

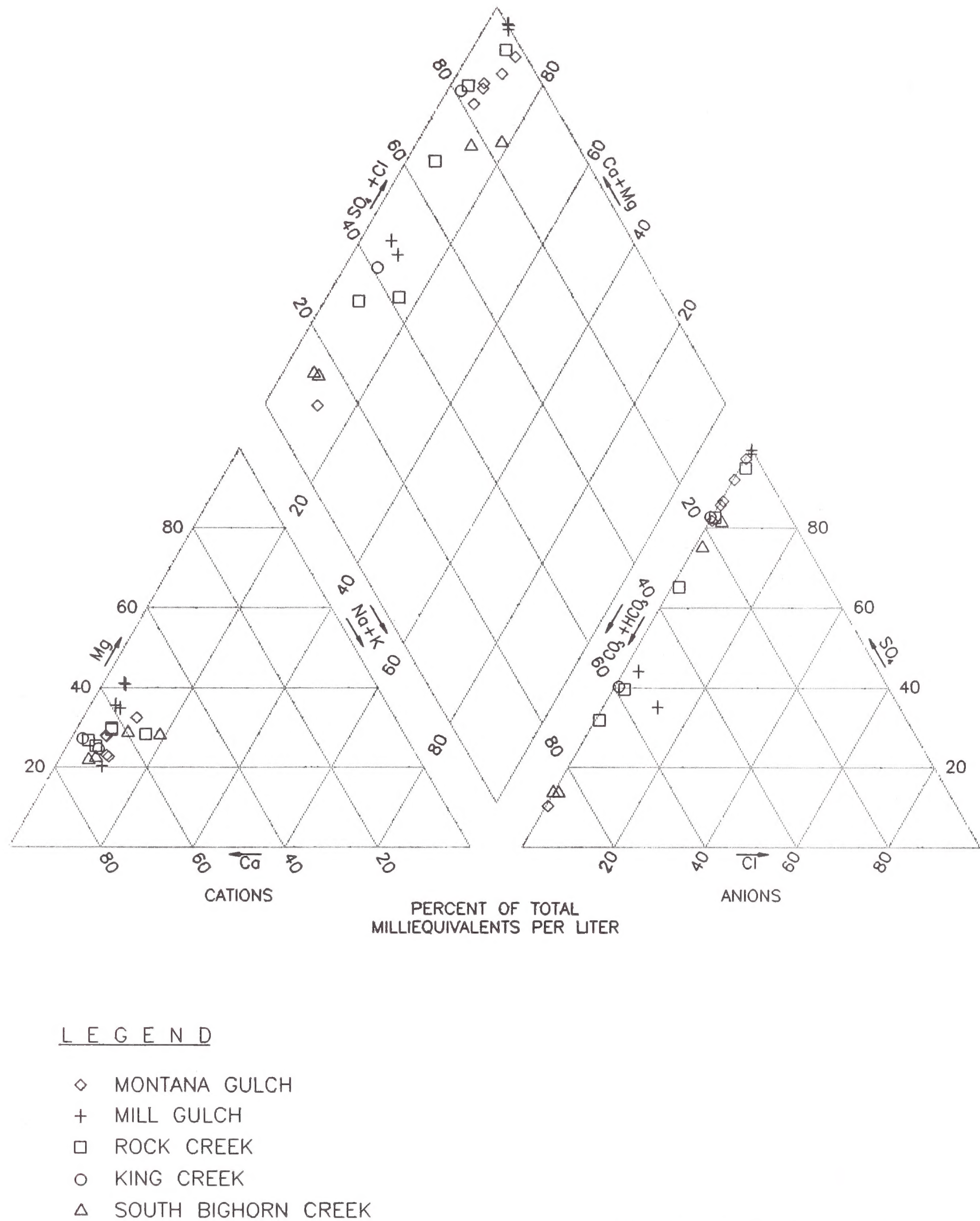


SOURCE: ZMI WATER QUALITY MONITORING REPORTS

PIPER TRILINEAR PLOT FOR ZORTMAN MINE SURFACE WATER SAMPLED MAY 1994

ZORTSW

FIG. 3.2–11



SOURCE: ZMI WATER QUALITY MONITORING REPORTS

PIPER TRILINEAR PLOT FOR LANDUSKY MINE SURFACE WATER SAMPLED MAY 1994

LANDSW

FIG. 3.2-12

TABLE 3.2-10
SURFACE WATER BASELINE WATER QUALITY (PRE-1979 DATA)

	Zortman												
	Ruby Gulch	Alder Gulch		Lodgepole Creek		Montana Gulch	Rock Creek		King Creek		Summary Statistics		
	Z-1 Upstream (1978)	Z-2 Upstream (1978)	Z-8 Midstream (1978)	Z-6 Below Developed Spring (1977)	Z-7 Above Reservation Boundary (1978)	L-2 Downstream (1977)	L-1 Downstream (1977-1978)		L-5 Upstream (1978)	L-6 Downstream (1978)			
No. of Samples	1	1	1	1	1	1	3		1	1	n	Minimum	Maximum
							Range	$\bar{x}$					
pH	7.4	7.8	7.6	7.5	8.0	8.4	7.9-8.2	8.0	6.9	7.5	11	6.9	8.4
SC µmhos/cm	325	315	370	360	375	330	395-559	501	490	525	11	315	559
TDS mg/l	190	183	206	NA	NA	NA	53-432	199	291	306	8	53	432
TSS mg/l	9.0	1.0	1.0	<1.0	<1.0	NA	11-11	11	NA	NA	6	1	11
SO_4 mg/l	110	74	70	12	8	61	53-112	82	134	95	10	8	134
CN mg/l	NA	NA	NA	NA	NA	ND	ND		NA	NA	0	0	0
NO_2/NO_3 mg/l	NA	NA	NA	NA	NA	NA	ND		NA	NA	1	0.03	0.03
NH_3 mg/l	NA	NA	NA	NA	NA	NA	NA		NA	NA	0	0	0
Hardness as $CaCO_3$ mg/l	139	139	168	178	183	NA	NA		231	245	7	139	245
Ca mg/l	41	44	50	46	52	NA	NA		70	77	7	41	77
Mg mg/l	9.0	7.0	10	15	13	NA	NA		14	13	7	7	15
K mg/l	2.0	2.0	2.0	1	2	NA	NA		2	2	7	1	2
Na mg/l	8.0	10	10	3	6	NA	NA		8	13	7	3	13
Cl mg/l	5.0	4.0	4.0	1	4	NA	NA		3	4	7	1	5
HCO_3 mg/l	31	85	122	207	220	NA	NA		122	207	7	31	220
Al mg/l	NA	NA	NA	NA	NA	NA	NA		NA	NA	0	0	0
As mg/l	NA	ND	(trc) 0.007	NA	(trc) <0.002	0.11	NA		NA	(trc) 0.01	3	0.002	0.01
Cd mg/l	NA	ND	NA	NA	NA	NA	NA		NA	NA	0	0	0
Fe mg/l	NA	NA	0.11	NA	0.03	NA	NA		NA	(trc) 0.17	3	0.011	0.17
Pb mg/l	NA	NA	NA	NA	NA	NA	NA		NA	NA	0	0	0
Mn mg/l	NA	NA	NA	NA	NA	NA	NA		NA	NA	0	0	0
Zn mg/l	NA	NA	NA	NA	(trc) <0.01	NA	NA		NA	NA	1	0.01	0.01

Data as dissolved concentrations unless otherwise stated.
TRC = Total Recoverable

analyses are available from the pre-1979 samples, the baseline range of concentrations measured for selected water quality indicators is pH (6.9 to 8.4), SC (315 to 559 μmhos/cm), TDS (53 to 432 mg/l), and sulfate (8 to 134 mg/l).

Zortman Surface Water Quality - 1979 to Present

Surface water monitoring stations found within the Zortman mine area are shown on Exhibit 1 (in EIS map pocket).

Ruby Gulch. Surface water quality data from Ruby Gulch has been reviewed from stations Z-1, Z-37, Z-10, Z-11, Z-15 (in the upper reaches), Z-1B (above the town of Zortman), Z-17 and Z-18 (below the town of Zortman) and Z-32, Z-33 and Z-34 (in the Ruby Flats area).

Representative surface water quality from throughout the length of Ruby Gulch is summarized in Table 3.2-11. Pre-1979 (baseline) data are available from monitoring station Z-1 only, in the upper reaches of Ruby Gulch. Data from Station Z-1 show the surface water to have had a pH of 7.4 and sulfate and TDS concentrations of 110 and 190 mg/l respectively in 1978, suggesting only minimal, if any, ARD effects from historical mining activity in the drainage. However, Ruby Gulch has been choked with tailing from historic mining operations since before ZMI began large-scale mining operations.

At sampling locations in the upper and middle reaches of Ruby Gulch (Z-1 and Z-15), impacts from ARD have been pronounced up until the fall of 1994, with depressed pHs and elevated concentrations of sulfate, TDS and metals. In the fall of 1993 stations Z-1 and Z-15 had pHs of 3.0 and 2.5, SC of 1,170 and 2,810 μmhos/cm, and sulfate concentrations of 615 and 2,080 mg/l, respectively. Figure 3.2-13 illustrates the changes in water quality at Z-1 since 1978. Although there is some variability in pH values, most pHs reported for the surface water samples from Ruby Gulch in 1992 and 1993 are below 5.0 and many are below 4.0. At station Z-1 total recoverable metal (trc) concentrations have exceeded Acute Chronic Aquatic Life Standards and/or Human Health criteria in the majority of samples for manganese, nickel, zinc and occasionally arsenic between 1979 and 1994. Cyanide has also been detected in the majority of the samples taken since 1978 at station Z-1. The deterioration of the surface water quality is clearly illustrated by the increase in sulfate and TDS concentrations shown on Figure 3.2-13 reaching maximums of 3,330 mg/l and 6,940 mg/l, respectively.

Monitoring station Z-1 is located downstream of the 89 leach pad, the 85/86 pad, the process plant and the mine pits. The poor surface water quality recorded at monitoring station Z-1 is closely related to the poor quality of the water seeping out of the 85/86 leach pad underdrain at the head of Ruby Gulch. There are several possible sources for this contaminated water. ARD seeping through from the Zortman pit walls and/or floor, ARD originating from rock used in the construction of the underdrains for 85/86 leach pad, ARD originating from sulfide bearing rocks excavated to place the 85/86 leach pad, or possibly acid generating material used in the construction of the 85/86 leach pad buttress.

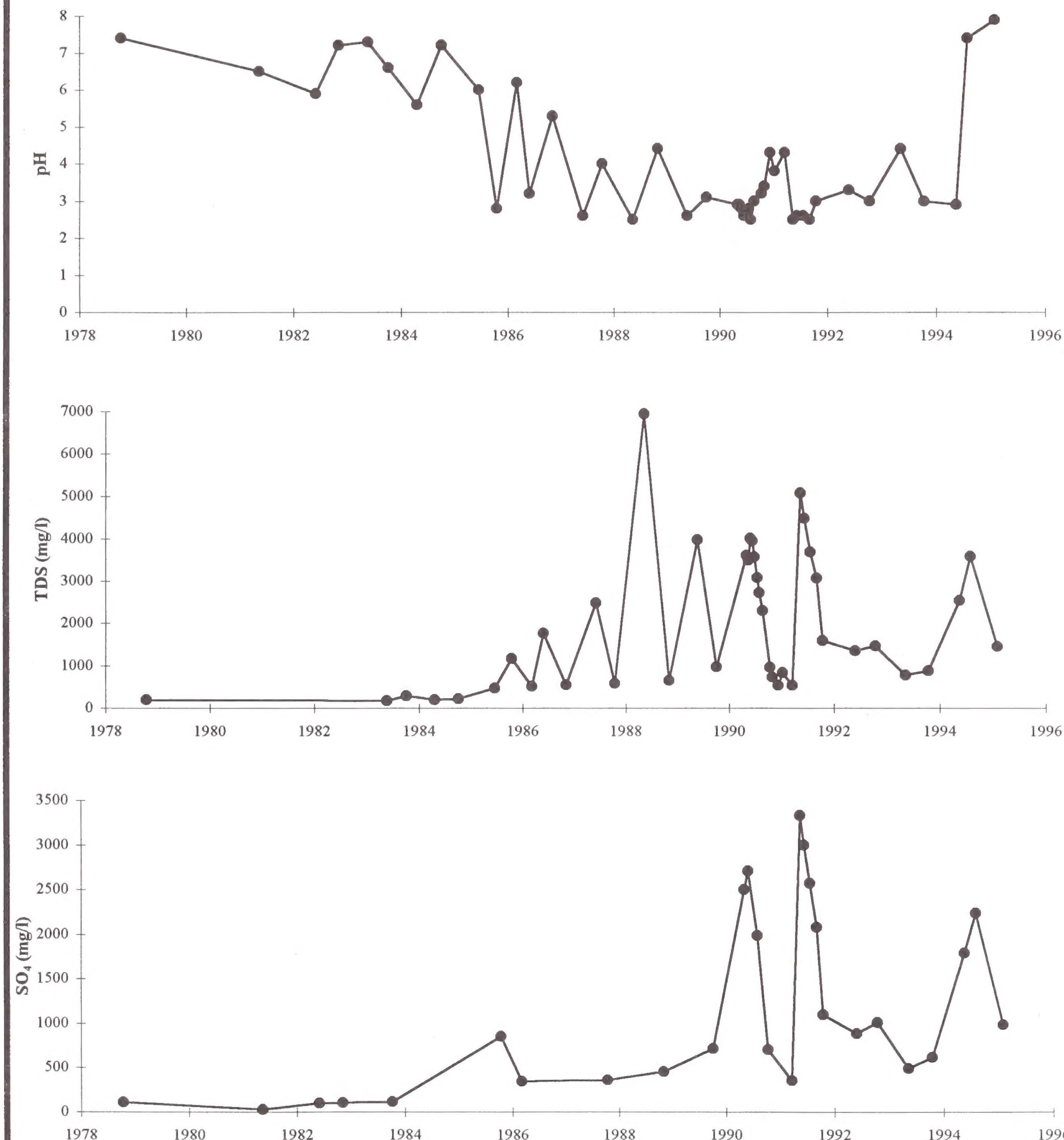
The surface water at the head of Ruby Gulch shows a record of declining quality between the fall of 1981 and the fall of 1990; however a significant drop in water quality commenced during 1985 with the pH at monitoring station Z-1 falling to a 2.8 and TDS rising to 1,170 mg/1 (Figure 3.2-13). This decrease in water quality correlates with the deepening of the O.K./Ruby pit areas (located just upgradient of the 85/86 leach pad). Although mining of these areas began in 1979, development of the pits consisted mostly of stripping of near surface materials prior to 1985. By the fall of 1985, however, these areas had been developed into deep pits and likely penetrated the "sulfide zone" (DEQ 1996). Pit highwall runoff studies have shown that precipitation contacting surfaces within the sulfide portions of these pits immediately becomes extremely acidic. Although loading did not commence until 1985, the 85/86 leach pad was actually constructed during 1984. Therefore, extremely low pH value at Z-1 were not observed until over a year after the suspect underlying bedrock was exposed and the leach pad underdrains emplaced. Cyanide was first detected at station Z-1 during 1981, prior to deepening of the pits and construction of the leach pad and appears to have derived from spills and/or leaks at the process plant. The apparent correlation of the decreased water quality with the deepening of the pits into the "sulfide zone" indicates that this is the primary source of the ARD, recharge water infiltrating through the pit flow and flowing towards Ruby Gulch downgradient along paths of preferential permeability.

Above and below the Zortman town site (surface water sampling locations Z-IB and Z-17), ARD effects are less severe, with some near-neutral pHs being reported for samples from sites Z-1B and Z-17. However, numerous pHs below 5.0 have been recorded at these stations along with elevated concentrations of sulfate, TDS, SC, and metal concentrations. Cyanide was detected in all three samples attained from Z-17 during 1990 and 1991

TABLE 3.2-11
RUBY GULCH SURFACE WATER QUALITY SUMMARY

BASELINE (PRE 1979)		OPERATION (POST 1979)					
		Z-1 Upstream (1979-1995)		Z-1B Midstream (1990-1995)		Z-32 Downstream (1990-1995)	
	Z-1 Upstream (1978)	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of samples	1	51		25		15	
pH S.U.	7.4	2.5-7.9	4.07	4.7-7.8	5.68	4.7-8.2	7.3
Sc μmhos/cm	325	175-4,990	1,905	106-2,340	1,233	791-1,310	983
TDS mg/l	190	176-6,940	2,115	81-2,450	1,204	518-1370	760
TSS mg/l	9.0	0.5-6,550	328	12-4,000	1,026	3-5810	1459
SO_4 mg/l	110	25-3,330	1,225	212-1,480	598	195-849	399
CN mg/l	NA	ND-1.38	0.108	ND-0.008	0.0035	ND-0.01	0.0025
NO_2/NO_3 mg/l	NA	0.32-23.4	3.80	ND-3.01	1.00	0.025-1.22	0.62
NH3	NA	ND-0.7	0.13	ND		ND	
Hardness as $CaCO_3$ mg/l	139	102-2,220	610	95-1,419	721	408-794	523
Ca mg/l	41.0	26-817	167	28-430	176	104-237	151
Mg mg/l	9.0	7-107	52.6	6-79	33.6	34-49	39
K mg/l	2.0	0.5-3.0	1.50	2-7	3.27	3-5	4.0
Na mg/l	8.0	8-82	20.0	3-23	10.0	11-37	23
Cl mg/l	5.0	0.5-29	6.48	0.5-42	8.77	2-5	3.6
HCO_3 mg/l	31.0	0.5-107	26.5	0.5-108	18.0	2-374	246
Al mg/l	NA	(trc)3.2-288	98.7	(trc) 1.7-81	29.8	(trc) ND-64.1	21.4
As mg/l	NA	(trc)ND-0.24	0.043	(trc) 0.01-0.13	0.0586	(trc) ND-0.18	0.06
Cd mg/l	NA	(trc)ND-0.35	0.113	(trc) ND-0.09	0.0349	(trc) ND-0.12	0.04
Cu mg/l	NA	(trc)0.03-14.8	3.938	(trc)0.02-1.34	0.4310	(trc)ND-2.76	0.92
Fe mg/l	NA	(trc)0.09-247	45.6	(trc) 2.4-43	13.0	(trc) 0.09-68	22.7
Pb mg/l	NA	(trc)ND-0.06	0.0106	(trc) ND-0.17	0.0600	(trc) ND-0.19	0.07
Mn mg/l	NA	(trc)0.01-27.6	10.61	(trc) 0.11-15.7	6.276	(trc) ND-16.4	5.6
Zn mg/l	NA	(trc)0.02-9.0	2.50	(trc) 0.08-13.5	4.326	(trc) 0.005-8.05	2.7

NA = Not Analyzed
ND - Not Detected
All concentrations dissolved unless otherwise stated
(tot) = Total
(trc) = Total Recoverable



NOTE: For field pH and specific conductivity beginning in June, 1994, please see Figure 3.2-15.

RUBY GULCH SURFACE WATER Z-1

FIG. 3.2-13

with an average concentration of 0.022 mg/l total cyanide. Station Z-17 is dry most of the time.

Data from the farthest downstream monitoring point for Ruby Creek (Z-32) have been gathered since 1990. The record shows moderate effects from mining activity with pHs ranging from 4.7 to 8.2, SC from 791 to 1,310 μmhos/cm, and sulfate from 195 to 849 mg/l (Figure 3.2-14). ARD impacts only appear to reach this far downstream after specific events, such as extreme rainfall or snowmelt.

Water quality monitoring throughout the length of Ruby Gulch records a period during the spring of 1991 with elevated concentrations of sulfate, TDS, SC and detectable levels of cyanide (Figure 3.2-14). These elevated concentrations appear to have been the result of unusually high surface water flow volumes and the associated flushing of reaction products from acid generating materials.

In order to improve the water quality within the Zortman area tributaries, ZMI has constructed and brought on line a water capture and treatment system, capturing water from Ruby Gulch and Alder Spur and Carter Gulch. Ruby Gulch currently contributes approximately 80 percent of influent (on average 80 gpm) and receives all of the water after treatment. The plant provides treatment by the use of a simple hydroxide precipitation process and can operate at a rate of 200 to 2,000 gpm depending on precipitation and seasonal operating conditions. Details regarding the water treatment plant are provided in Section 2.5.1.6.

Figure 3.2-15 illustrates the change in pH and SC at Station Z-1 (upper Ruby Gulch) once the treatment process was initiated. An immediate increase in pH can be seen, although a reduction in the specific conductivity was not attained until August 1994. At least two periods of water quality degradation have been observed downstream of the capture and treatment systems during 1995 (Figure 3.2-15). Table 3.2-12 shows the concentrations of metals at surface water monitoring stations Z-1 and Z-15 (approximately 1,600 feet downstream), prior to and after initiation of water treatment. The significant concentrations of aluminum and iron are effectively removed from the water down to below detection limits; the more moderate levels of copper, zinc and manganese are also reduced significantly.

<u>Alder Gulch, Carter Gulch and Alder Spur</u>. Surface water quality data for the Alder Gulch drainage was reviewed from Stations Z-13 (toe of the Alder Gulch waste dump), Z-2 and Z-3A (above the Alder Spur/Alder Gulch confluence), Z-14 and Z-6A (within Alder Spur), and Z-8 and Z-16 (below the Alder Spur/Alder Gulch confluence).

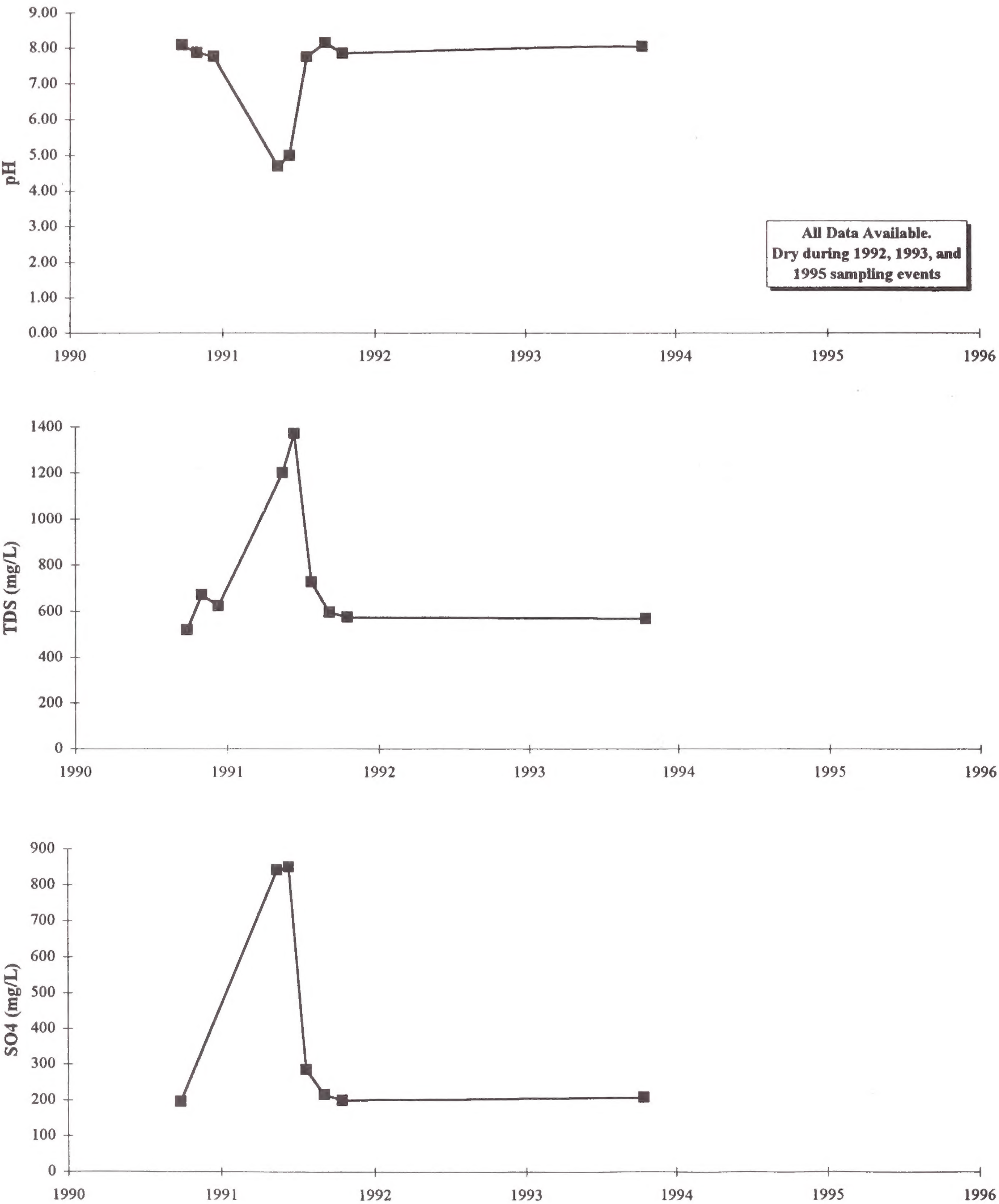
Water quality data prior to initiation of Zortman mining activity in 1979 is available from two monitoring stations Z-2 (in the upper reaches of Alder Gulch) and Z-8 (below the Alder Gulch/Alder Spur confluence), these "baseline" data and the following "operational" data are shown on Table 3.2-13. The pre-1979 data show pHs of 7.8 and 7.5, specific conductivity values of 315 and 370 μmhos/cm, sulfate concentrations of 74 and 70 mg/l, and total dissolved solids concentrations of 183 and 206 mg/l, suggesting little or no effect from historic mining activities. The initial analysis reported for the surface water monitoring station Z-3A, dated 5/29/87, shows minimal or no effects from current mining operations.

Initial analyses from other surface water sampling stations in the Alder Gulch/Spur area, such as Z-6A and Z-14, dated 5/29/87 and 5/1/84, respectively, show near-neutral pHs but higher specific conductivity values and higher concentrations of sulfate and TDS than the initial analyses for locations Z-2, Z-8, and Z-3A. The Z-6A and Z-14 sampling locations reflect drainage from Alder Spur.

Carter Gulch is the uppermost tributary to Alder Gulch. Results of chemical analyses for Carter Gulch surface water show decreasing pH values and increasing specific conductivity, sulfate and TDS. Available data from monitoring station Z-13 located at the toe of the Alder Gulch waste dump show the surface water to be impacted by ARD with pHs ranging from 3.4 to 7.3 TDS from 350 to 6,420 and sulfate from 735 to 4,520 mg/l. Samples from station Z-13 also regularly have elevated levels of manganese, nickel, lead and zinc.

During the period from 1978 to 1995, depending on the specific site in Alder Gulch, there are episodes of decreasing pH, with overall trends of increasing specific conductivity values and increasing concentrations of sulfate, TDS, and metals. The pH values recorded for sampling location Z-2 ranged from 3.8 to 7.9 (Figure 3.2-16). The capture system installed at the base of the Alder Gulch waste rock dump currently captures and pumps an average of 10 gpm to the Zortman treatment plant.

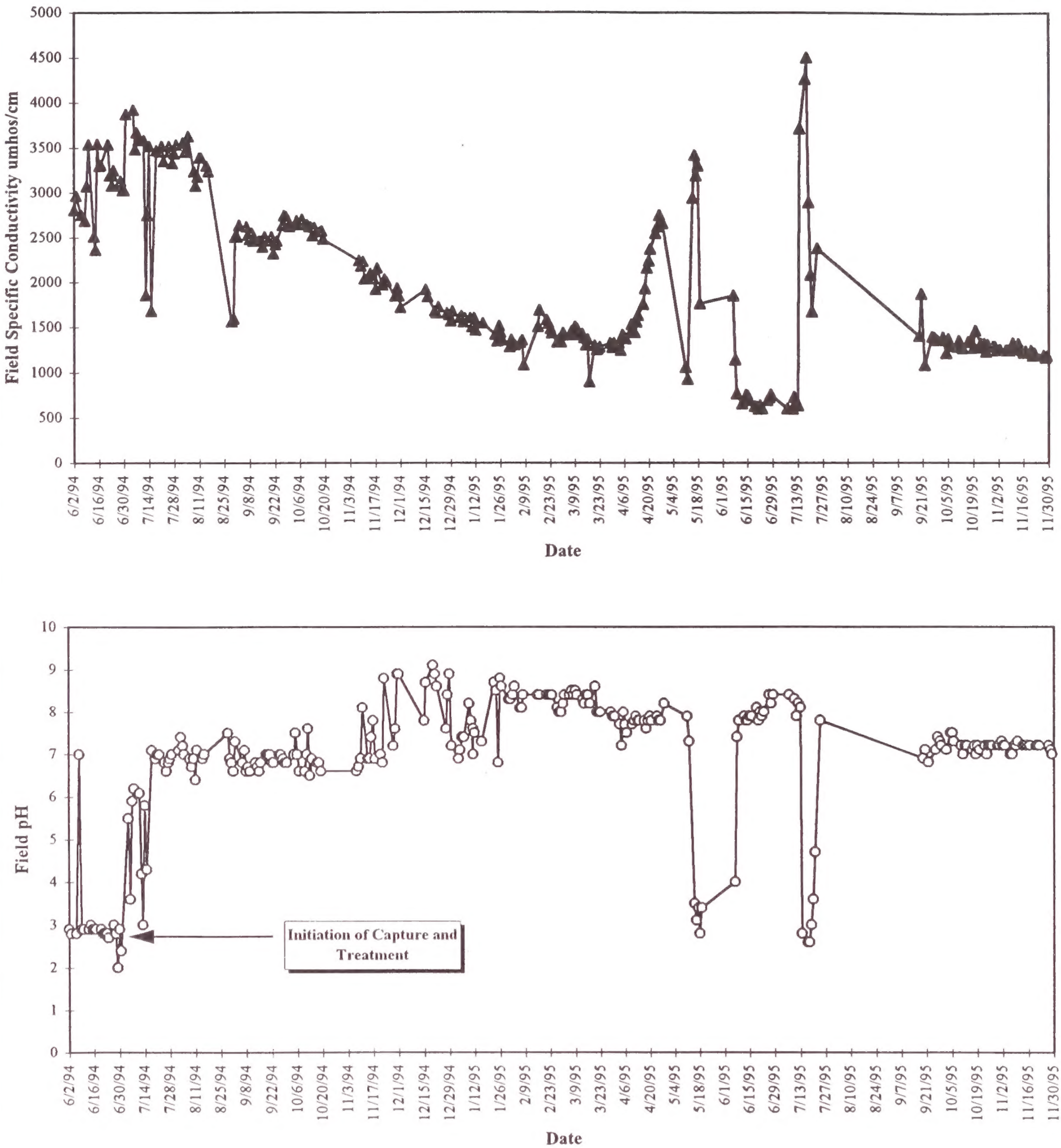
Monitoring station Z-14 in the upper reaches of Alder Spur has a history of decreasing water quality since 1984, and in the latest round of samples in the Fall of 1995 had a pH of 4.1, a SC of 2,210 μmhos/cm and a sulfate concentration of 1,520 mg/l. Monitoring station Z-6A in the lower reaches of Alder Spur also shows a



SOURCE: ZMI WATER QUALITY MONITORING REPORTS

SURFACE WATER QUALITY
MONITORING STATION Z-32
DOWNSTREAM RUBY GULCH

FIG. 3.2-14



SOURCE: ZMI OPERATIONAL MONITORING DATA

OPERATIONAL SURFACE WATER QUALITY MONITORING STATION Z-1 RUBY GULCH

FIG. 3.2-15

TABLE 3.2-12
CAPTURE AND TREATMENT EFFECTS ON WATER QUALITY AT MONITORING STATIONS Z-1 AND Z-15 RUBY GULCH

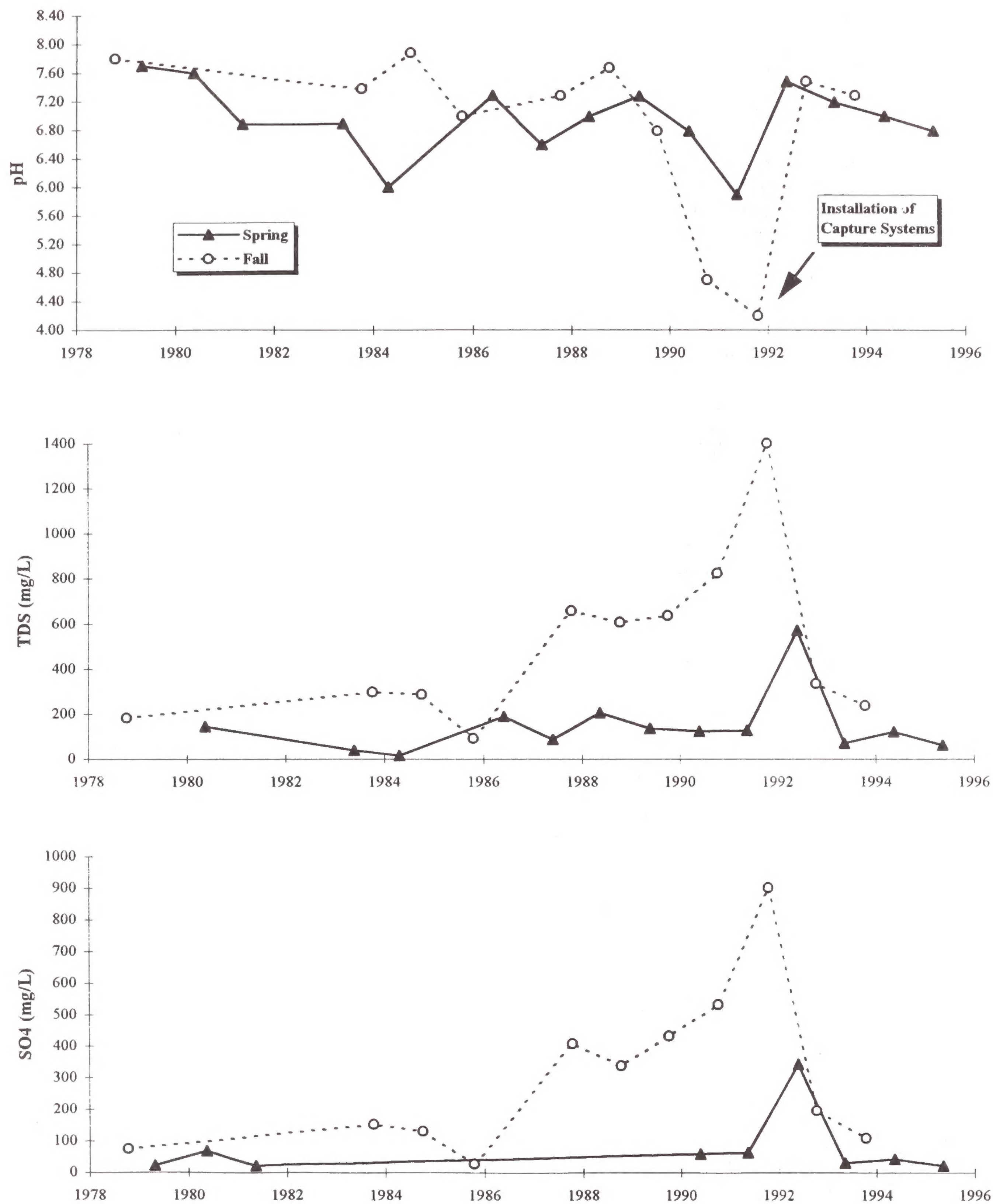
Description	Sample Date (1994)	mg/l AL	mg/l Ag	mg/l Cu	mg/l Fe	mg/l Ca	mg/l Pb	mg/l Zn	mg/l Cr	mg/l Cd	mg/l Mg	mg/l Mn	mg/l SO_4
Z-1	19-May	160	0.00	5.38	53.80	162	0.00	5.06	0.11	0.160	90.00	19.30	1,790
Z-1	13-Jun	143	0.01	5.40	64.00	106	0.04	4.50	0.24	0.17	80.00	20.60	1,971
Z-1	06-Jul	33.67	0.00	1.47	13.80	514.0	0.10	1.10	0.08	0.04	70.00	9.70	NA
Startup of Water Treatment Plant													
Z-1	01-Aug	4.10	0.00	0.03	2.18	786	0.00	0.05	0.00	0.00	44	2.14	2240
Z-1	10-Aug	0.00	0.01	0.31	0.25	3,400	0.00	0.03	0.08	0.03	1,000	5.00	2,093
Z-1	12-Sep	0.00	0.00	0.04	0.20	403	0.00	0.01	0.02	0.01	110	6.70	1,385
Z-1	11-Oct	0.00	0.01	0.06	0.23	430	0.04	0.04	0.00	0.01	50	2.59	1,407
Z-15	19-May	154	0.006	5.23	50.40	160	0.03	4.73	0.10	0.159	90	18.50	1800
Z-15	13-Jun	60.67	0.00	2.18	14.60	44.50	0.03	1.60	0.16	0.06	27.00	7.50	763
Z-15	06-Jul	33.33	0.00	1.39	25.90	503	0.09	1.00	0.06	0.06	70	10.40	NA
Startup of Water Treatment Plant													
Z-15	09-Aug	0.00	0.01	0.06	0.43	4,500	0.00	0.02	0.10	0.01	1,000	3.90	1,557
Z-15	12-Sep	0.00	0.00	0.07	1.38	389	0.00	0.04	0.05	0.01	70	6.40	1,590
Z-15	11-Oct	0.00	0.00	0.05	0.47	425	0.07	0.05	0.01	0.02	70	2.7	1,654

Note: 0.00 = below the detection limit
NA = Not analyzed

TABLE 3.2-13
ALDER GULCH SURFACE WATER QUALITY SUMMARY

	BASELINE (PRE 1979)		OPERATIONAL (1979 - 1993)			
			Upstream Z-2 (1979-1995)		Midstream Z-8 (1979-1995)	
	Upstream Z-2 (1978)	Midstream Z-8 (1978)	Range	$\bar{x}$	Range	$\bar{x}$
No. of samples	1	1	45		49	
pH S.U.	7.8	7.6	3.8-7.9	6.38	4.3-8.3	6.97
SC μmhos/cm	315	370	53-1930	531	83-1,410	516
TDS mg/l	183	206	15-2160	455	22-1,370	401
TSS mg/l	1.0	1.0	ND-73	11.98	ND-460	48.1
SO_4 mg/l	74	70	14-1420	255	17-904	117
CN mg/l	NA	NA	ND	ND	ND-0.48	0.019
NO_2/NO_3 mg/l	NA	NA	0.01-2.96	0.66	ND-1.03	0.22
NH_3 mg/l	NA	NA	ND		ND-0.4	0.08
Hardness as CaCO3 mg/l	139	168	24-918	249	38-768	257
Ca mg/l	44	50	7-220	66.6	11-205	62.1
Mg mg/l	7.0	10	1-90	17.5	3-62	15.6
K mg/l	2.0	2.0	1-5	2.23	1-3	2.06
Na mg/l	10.0	10	1-47	8.89	1-17	8.00
Cl mg/l	4.0	4	ND-6	1.45	ND-8.0	3.05
HCO_3 mg/l	85	122	0.5-157.0	47.9	2-172	73.2
Al mg/l	NA	NA	(trc)0.30-57.06	9.15	(trc)ND-20.6	2.38
As mg/l	ND	(trc)0.007	(trc)ND-0.005	0.0032	(trc)ND-0.013	0.0038
Cd mg/l	ND	NA	(trc)ND-0.172	0.0256	(trc)ND-0.109	0.0095
Cu mg/l	NA	ND	(trc)ND-2.01	0.2153	(trc)ND-0.63	0.0559
Fe mg/l	NA	0.11	(trc)ND-1.44	0.260	(trc)ND-5.5	0.649
Pb mg/l	NA	NA	(trc)ND-0.02	0.0064	(trc)ND-0.03	0.0104
Mn mg/l	NA	NA	(trc)ND-25.2	3.45	(trc)ND-13.5	0.950
Zn mg/l	NA	NA	(trc)ND-3.65	0.45	(trc)ND-3.14	0.2008

NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated
(tot) = Total
(trc) = Total Recoverable



SOURCE: ZMI WATER QUALITY MONITORING REPORTS

SURFACE WATER QUALITY
MONITORING STATION Z-2
MIDSTREAM ALDER GULCH

FIG. 3.2-16

history of poor water quality, with numerous detections of cyanide reaching a maximum of 0.07 mg/l total cyanide in 1990. Sulfate and dissolved solids concentration are also elevated at station Z-6A, but the pH of the water has remained near neutral.

Cyanide contamination in Alder Spur can be traced to a major spill (pipeline break) in 1984 and the 1986-87 land application of 20 million gallons of cyanide process solution treated with calcium hypochlorite.

Due to impacts associated with drainage from the waste rock dump in Carter Gulch and leach pads and buttresses (built with waste rock) in Alder Spur, solution capture systems were installed during July 1992 below the waste rock dump and the 83/84 pads. The capture system currently pumps an average of 10 gpm to the Zortman treatment plant. Figure 3.2-17 illustrates water quality at station Z-8 below the confluence of Alder Gulch and Alder Spur. The monitoring record at Z-8 shows generally good water quality, with only occasional events of reduced quality. An overall improvement in water quality is however apparent at Z-8 after construction of the capture ponds in 1992 (Figure 3.2-17); a similar improvement is recognizable at station Z-2.

The farthest downstream monitoring station in Alder Gulch receiving drainage from all its tributaries is station Z-16 (Exhibit 1). This station is often dry but between 1990 and 1995, has had an average pH, SC and sulfate of 6.8, 526 μmhos/cm, and 223 mg/l respectively, indicating that the impacted surface water either infiltrates prior to reaching this downstream monitoring station, or improves substantially in quality as it flows downstream due to neutralization and attenuation.

Goslin Flats. Surface water monitoring in Goslin Flats began in 1990. Water quality data are available from three stations down the length of the Gulch (Z-21, Z-35 and Z-22); the other two stations have been dry since their installation. Representative water quality data from these three stations are shown on Table 3.2-14.

Despite the lack of any mining operations in Goslin Flats, indicators often associated with ARD are moderately high at each of the stations. For example station Z-22 near the bottom of the gulch has an average SC concentration of around 1,747 μmhos/cm, TDS of 1,468 mg/l and sulfate of 813 mg/l. The pH of the water has however remained neutral since monitoring started in 1990 and no cyanide has been detected. Stations Z-21 and Z-35 have similar water chemistry with neutral pHs, moderately high sulfate and TDS. The neutral pH but high sulfate etc. are due to ongoing water rock interaction with sediments partially made up of the underlying mineral-rich shales which are reduced and have high sulfate concentrations. This high sulfate, high TDS water type is clearly illustrated on Figure 3.2-11 where it plots among surface waters with ARD impacts. Such high TDS, high sulfate, alkaline pH waters are commonly associated with continental and marine shales and represents baseline conditions for the Goslin Gulch drainage basin.

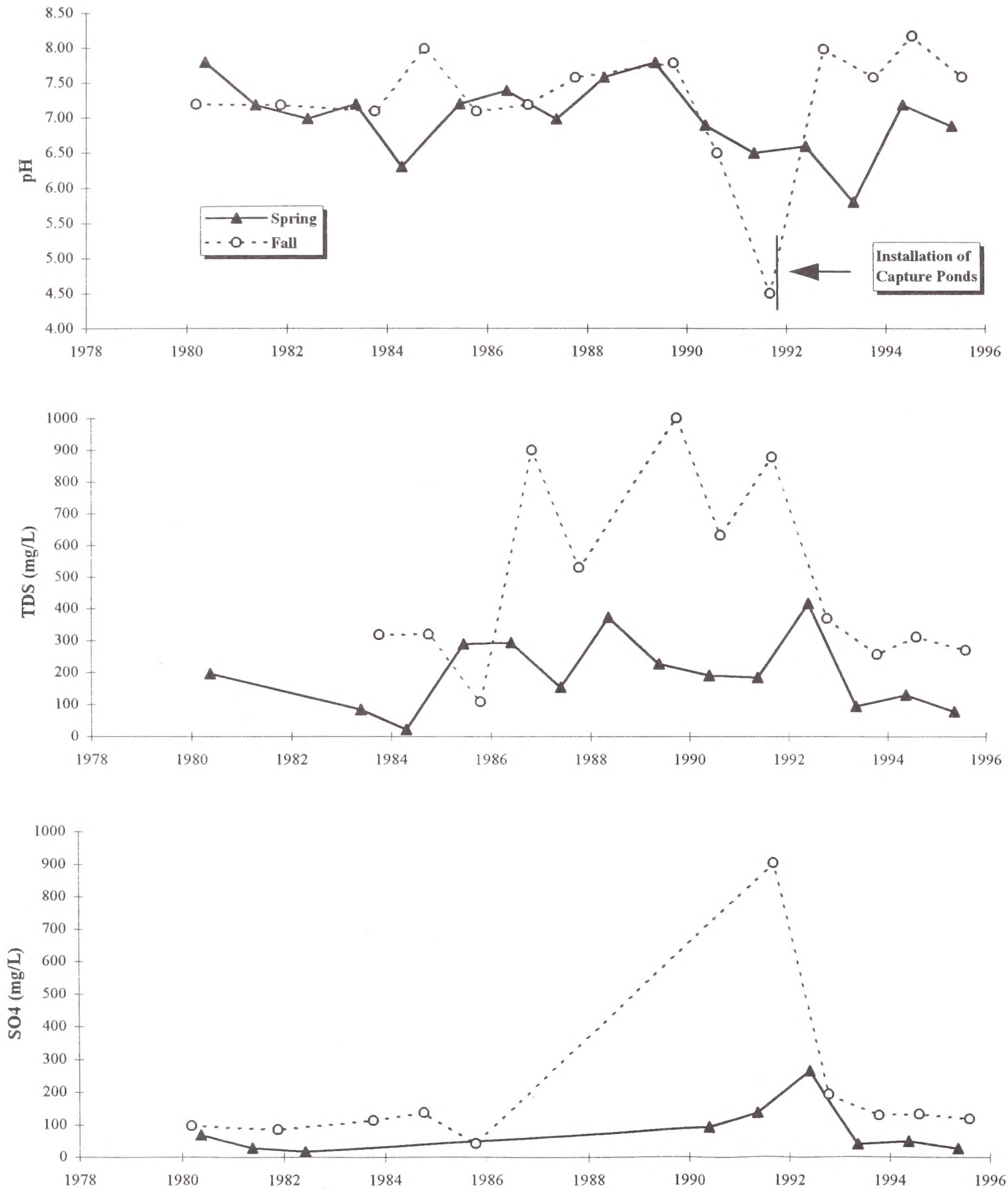
Lodgepole Creek. Lodgepole Creek and Glory Hole Creek drain approximately 15 square miles of the northern portion of the Little Rocky Mountains upgradient of the Fort Belknap Indian Reservation. The headwaters of Glory Hole Creek include part of the present day Zortman Mine workings.

Surface water quality data for the Lodgepole Creek drainage is available from stations Z-5, Z-30 and Z-28 (upstream Lodgepole Creek), Z-29 (at the confluence of Glory Hole Creek and Lodgepole Creek) and Z-7 (downstream near the boundary of the Fort Belknap Indian Reservation).

Table 3.2-15 summarizes the surface water quality data from Lodgepole Creek drainages between 1978 and 1995. Water quality data from monitoring stations Z-28 in the headwaters of Lodgepole Creek shows one sample of poor water quality with a pH of 12.2, SC concentration of 2,760 μmhos/cm, and 611 mg/l TDS during the spring of 1990. The extremely high pH suggests that this was due to laboratory error. The next sample taken one month later returned to concentrations typical of Lodgepole Creek with a pH of 7.4, SC of 133 μmhos/cm, and TDS of 110 mg/l. Monitoring data from station Z-5 in Glory Hole Creek shows that nitrate concentrations in 1981 and 1982 were 0.09 mg/l for one sample and below detection (0.05 mg/l) for two samples. Nitrate concentrations from 1989 to 1993 range up to a maximum of 2.1 mg/l. This increase in nitrate in the headwaters of Lodgepole Creek may be due to residual nitrates from blasting activities at the Zortman pits or due to fertilization of reclaimed areas.

Water quality from further downstream at station Z-7 does not show any discernable impacts from mining activities with maximum concentrations of nitrate, sulfate, SC and TDS of 0.68 mg/l, 36 mg/l, 433 μmhos/cm, and 267 mg/l, respectively.

Surface water quality at Lodgepole Creek overall appear to have had minimal impacts from mining activity, and only in the uppermost reaches.



SOURCE: ZMI WATER QUALITY MONITORING REPORTS

SURFACE WATER QUALITY
MONITORING STATION Z-8
MIDSTREAM ALDER GULCH

FIG. 3.2-17

TABLE 3.2-14
GOSLIN FLATS REPRESENTATIVE SURFACE WATER QUALITY SUMMARY

	OPERATIONAL BUT REPRESENTATIVE OF BASELINE					
	Upstream Z-21 (1990-1994)		Upstream Z-35 (1990-1994)		Downstream Z-22 (1990-1994)	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of samples	15		12		15	
pH S.U.	7.40-7.8	7.62	7.40-8.0	7.7	6.7-7.8	7.59
SC μmhos/cm	1,540-1,930	1,769	1,070-1,480	1,297	1,530-1,990	1,747
TDS mg/l	1350-1550	1,435	851-1,040	981	1,290-1,720	1,468
TSS mg/l	ND-393	32.9	ND-10.00	2.75	27-1,370	433
SO_4 mg/l	709-1,020	776	414-510	480	709-1,020	813
CN mg/l	ND		ND		ND	
NO_2/NO_3 mg/l	2.35-8.07	3.94	0.36-1.61	0.59	ND-0.14	0.044
NH_3 mg/l	ND		ND		ND	
Hardness as CaCO3 mg/l	792-962	889	635-749	702	835-1070	924
Ca mg/l	136-172	155	112-128	121	199-256	221
Mg mg/l	110-134	122	86-104	97	88-106	91
K mg/l	5-10	7.3	6-9	6.58	4-9	6.36
Na mg/l	91-125	107	38-53	48.7	90-124	105.4
Cl mg/l	9-57	15.1	3-14	4.17	5-10	7.9
HCO_3 mg/l	317-394	371	332-382	366		336
Al mg/l	(trc) ND		(trc)ND-0.10	0.058	(trc)0.20-2.50	1.00
As mg/l	(trc)ND-0.04	0.0055	(trc) ND		(trc)ND-0.007	0.0033
Cd mg/l	(trc) ND		(trc) ND		(trc) ND	
Cu mg/l	(trc)ND		(trc)ND		(trc)ND-0.01	0.0056
Fe mg/l	(trc)ND-0.3	0.1335	(trc) ND		(trc)0.40-4.55	2.28
Pb mg/l	(trc)ND-0.020	0.0065	(trc)ND-0.01	0.0058	(trc)ND-0.03	0.0089
Mn mg/l	(trc)0.020-0.060	0.0358	(trc)ND		(trc)0.020-0.47	0.1167
Zn mg/l	(trc)ND-0.070	0.0125	(trc)ND-0.02	0.0083	(trc)0.005-0.03	0.167

NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated
(tot) = Total
(trc) = Total Recoverable

TABLE 3.2-15
LODGEPOLE CREEK SURFACE WATER QUALITY SUMMARY

	Operational (But Representative of Baseline)					
	Upstream Z-28 (1990 - 1995)		Upstream Z-29 (1990 - 1995)		Downstream Z-7 (1990 - 1995)	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of samples	**25**		**24**		**16**	
pH S.U.	6.7-12.2	7.65	6.9-8.2	7.79	7.4-8.5	8.18
SC μmhos/cm	78-2,760	317	140-428	316	201-433	334
TDS mg/l	31-611	125	80-245	184	83-267	194
TSS mg/l	ND-35	8.3	ND-512	40.5	ND-118.0	4.75
SO_4 mg/l	8.0-19.0	11.7	13-40	23.3	12-36	22.6
CN mg/l	ND		ND		ND	
NO_2/NO_3 mg/l	ND-0.35	0.16	ND-0.68	0.28	ND-0.13	0.0457
NH_3 mg/l	ND		ND		ND	
Hardness as CaCO3 mg/l	33.0-102	62.3	61-260	178	93-252	186
Ca mg/l	14-32	19.4	18-66	47.1	26-69	51.9
Mg mg/l	1.00-6.00	2.05	4-24	15.6	7-19	13.9
K mg/l	ND-1.0	0.69	ND-2.0	1.21	1-2	1.62
Na mg/l	1.0-286	30.3	1-3	2.37	3-7	4.64
Cl mg/l	ND-2.0	0.70	ND-3	0.79	ND-4.0	0.85
HCO_3 mg/l	32-109	64.4	66-276	187	108-274	203
Al mg/l	(trc)0.1-0.60	0.47	(trc)ND-7.1	0.71	(trc)ND-1.1	0.146
As mg/l	(trc) ND		(trc)ND-0.005	0.0026	(trc)ND	
Cd mg/l	(trc) ND		(trc)ND-0.006	0.0006	(trc)ND	
Cu mg/l	(trc) ND		(trc)ND-0.02	0.0056	(trc)ND	
Fe mg/l	(trc)0.07-0.84	0.02554	(trc)ND-11.4	1.06	(trc)ND-0.68	0.0906
Pb mg/l	(trc)ND-0.03	0.0054	(trc)ND-0.03	0.0083	(trc)ND	
Mn mg/l	(trc) ND	0.014	(trc)ND-0.93	0.0764	(trc)ND	
Zn mg/l	(trc)ND-0.03		(trc)ND-0.06	0.0194	(trc)ND	

NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated
(tot) = Total
(trc) = Total Recoverable

Beaver Creek. Surface water quality data is available from three monitoring stations throughout the upper length of the Beaver Creek drainage. Sampling locations include Z-27 (headwaters, draining a canyon with exposed limestone) and stations Z-31 and Z-39 (at downstream tributary confluences) (Exhibit 1). Table 3.2-16 summarizes the surface water quality data from these stations. Water quality from throughout the drainage is unimpacted by any mining related activity with maximum values for SC of 399 μmhos/cm, sulfate 20 mg/l and a minimum pH of 6.8. Metals concentrations in the water samples are either very low or below detection limits. Water quality data from the Beaver Creek drainage may be representative of "baseline conditions" for an unmineralized drainage within the Little Rocky Mountains.

Summary of Zortman Surface Water Quality - 1979 to 1995

In summary, the recent and historical surface water quality data reviewed for the Zortman mining area indicate the following:

Ruby Gulch

- A water quality sample from pre-1979 is available from station Z-1 in the upper reaches of Ruby Gulch, showing a pH of 7.4, sulfate concentration of 110 mg/l, and TDS of 190 mg/l, suggesting minimal or no effects from ARD at that time.

- ARD-impacted surface water has reached well downstream of the town of Zortman. Impacts of mining operations include slight detections of cyanide, variable or decreasing pH values, increased specific conductivity and increased concentrations of sulfate, total dissolved solids (TDS), and metals.

- The monitoring record suggests that ARD impacts only reach the lower levels of the drainage after specific events, possibly periods of high precipitation or snowmelt.

- Ruby Gulch is the most impacted drainage in the Zortman and Landusky mining areas, both by the physical impact of the historic mining activities (tailing deposition), and recent mining ARD effects.

- Construction of the Ruby Gulch capture and treat system has begun to significantly improve surface water quality of the drainage, although some downstream water degradation has been monitored during 1995.

Alder Gulch

- A pre-1979 water quality sample is available for both stations Z-2 and Z-8 in Alder Gulch. These samples had neutral pHs of 7.8 and 7.6, sulfate concentrations 74 and 70 mg/l, and TDS of 183 and 206 mg/l, respectively. The data indicate minimal or no effects from ARD at that time.

- Water quality in Carter Gulch is presently impacted by ARD with monitoring station Z-13 having a pH of 3.5, SC of 3,980 μmhos/cm and sulfate of 3,420 mg/l in the fall of 1995. This ARD drains from the Alder Gulch waste rock dump and is currently being captured and pumped to the Ruby Gulch water treatment plant.

- Water Quality in Alder Spur is presently impacted by ARD with monitoring station Z-14 having a pH of 4.1, SC of 2,210 μmhos/cm, and sulfate of 1,530 mg/l, in the fall of 1995. Cyanide detections and ARD contamination within Alder Spur, can be traced to several different sources. The 83/84 leach pad complex with a cyanide pipeline break in 1984, dike/foundation construction for the heap leach pads, and the 1986-87 LAD of 20 million gallons of process solution treated with calcium hypochlorite on the east side of Carter Butte. Poor quality seepage is also being captured at Alder Spur and pumped to Ruby Gulch for treatment.

- Water quality has improved at sampling location Z-8, below the confluence of Alder Spur with Alder Gulch, since 1992 due to installation of solution capture systems.

Goslin Flats

- Surface water quality in Goslin Flats is characterized by a near neutral pH but high levels of sulfate, SC and TDS. The relatively high levels of dissolved constituents but near neutral pH is the result of natural water-rock interaction with sediments derived from the underlying shales in Goslin Flats.

Lodgepole Creek

- The available surface water quality data within the Lodgepole Creek drainage shows that impacts have been minimal and restricted to Glory Hole Creek.

TABLE 3.2-16
BEAVER CREEK SURFACE WATER QUALITY SUMMARY

	OPERATIONAL (But Representative of Baseline)					
	BEAVER CREEK					
	Upstream Z-27 (1990-1995)		Downstream Z-31 (1990-1995)		Downstream Z-39 (1994-1995)	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of samples	26		22		3	
pH S.U.	6.8-7.9	7.3	7.1-8.0	7.7	7.9	8.1
SC μmhos/cm	74.8-399.0	180	135-252	194	168-310	232
TDS mg/l	41-236	119	65-158	123	127-243	157
TSS mg/l	ND-44	11.3	0.5-8.0	3.8	ND-8	4.3
SO_4 mg/l	3-18	7.3	5.0-16	7.3	6-20	11.5
CN mg/l	ND		ND		ND	
NO_2/NO_3 mg/l	ND		ND		ND	
NH_3 mg/l	ND		ND		ND	
Hardness as CaCO3 mg/l	37-178	91.8	69-124	98.2	82-171	117
Ca mg/l	13-61	28.3	21-38	29.0	25-50	35.3
Mg mg/l	1-6	3.0	4-7	5.8	5-11	7.5
K mg/l	1-2	1.5	ND		ND-1.0	0.63
Na mg/l	1-3	2.3	2-4	3.3	3-4	3.3
Cl mg/l	ND-2.0	0.88	0.5-2.0	0.83	ND	
HCO_3 mg/l	30-203	92.8	76-155	116	100-188	135
Al mg/l	(trc)0.05-2.10	0.94	(trc)0.05-.60	0.20	(trc) ND-0.7	0.4
As mg/l	(trc) ND		(trc) ND		(trc) ND	
Cd mg/l	(trc)0.0001-0.0030	0.008	(trc)ND-0.003	0.0009	(trc) ND	
Cu mg/l	(trc) ND		(trc) ND		(trc) ND	
Fe mg/l	(trc)0.05-1.21	0.54	(trc)ND-0.32	0.01	(trc) ND-0.5	0.2
Pb mg/l	(trc)0.001-0.02	0.008	(trc)ND-0.02	0.006	(trc) ND	
Mn mg/l	(trc)0.01-0.27	0.07	(trc) ND		(trc) ND	
Zn mg/l	(trc)0.005-0.04	0.02	(trc)0.005-0.070	0.01	(trc) ND-0.02	0.02

Note: No pre-1979 (baseline data) available
NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated

Beaver Creek

- The surface water quality within the Beaver Creek exhibits no impacts from existing mining operations, and may represent "baseline conditions" for non-mineralized drainages of the Little Rocky Mountains.

Landusky Surface Water Quality

Surface water monitoring stations found within the Landusky mine area are shown on Exhibit 2 (EIS map pocket).

Rock Creek/Sullivan Creek. Surface water monitoring stations reviewed from Rock Creek included L-27 and L-28 (Sullivan Creek Tributary), L-23 and L-29 (main reach of Rock Creek), L-4 and L-10 (below the confluence with Mill Gulch) and L-1 (downstream of confluence with Montana Gulch).

Table 3.2-17 summarizes baseline and operational water data from within Rock Creek. Consistent surface water quality data for Sullivan Creek is limited to after 1991 when the 91 leach pad was constructed, although a few samples from the Upper Rock Creek drainage were collected in 1988 during investigations for the proposed 91 leach pad site.

Monitoring station L-28 located at the toe of the leach pad receives water directly from the leach pad underdrain and appears to have become intensely affected by ARD, as illustrated by increases in sulfate, TDS and SC concentrations. During 1991 and 1992 sulfate, TDS and SC reached maximum concentrations of 9,960 mg/l, 14,700 mg/l and 10,700 μmhos/cm, respectively. Since 1991 the pH at L-28 has been consistently low, between 2.7 and 3.9 (Table 3.2-17). This water from the underdrain flows at less than 1/2 gpm and is currently captured by a contingency pond and then pumped back into the process circuit. Captured and recirculated water at Sullivan Creek currently averages a flow of 20 gpm. Also of note are anomalously high concentrations of chloride (Cl) at 85 mg/l and the detections of ammonia at 1.1 mg/l and Nitrate +Nitrite at 4.78 mg/l on 10/15/92. The elevated nitrates are likely due to fertilizers being used on the '91 dike for revegetation or blasting residues on the rocks used in the '91 dike.

Monitoring station L-27 located a few hundred feet further down Sullivan Creek has demonstrated a similar decline of water quality. The ARD effects seen in Sullivan Creek are thought to be derived from acid generating material used in the construction of the 91 leach pad dike or due to oxidation of acid-generating bedrock exposed during construction of the pad.

Surface water is also sampled at monitoring station L-29, above the confluence of Sullivan and Rock creeks. This tributary does not receive drainage from any recent mining-related activities but does contain a historic adit upstream of monitoring station L-29. Although the record of analysis is limited to 1990 through 1994, no effects from mining activity are apparent, demonstrated by consistently neutral pH values and low sulfate and TDS (Table 3.2-17). Water quality data from station L-29 may be representative of baseline surface water conditions for the Rock Creek/Sullivan Creek area.

Located just upstream of the town of Landusky, monitoring station L-4 shows surface water with a near neutral pH and low TDS and sulfate concentrations. Monitoring station L-1 is located in Rock Creek down stream of the confluence of Mill and Montana Gulches, and thus represents the total surface water drainage from the southern side of the Landusky mining operation. Pre-1979 (baseline) data from station L-1 shows the pH to have ranged between 8.0 and 8.2, sulfate between 53 and 112 mg/l and SC from 395 to 609 μmhos/cm (Table 3.2-17). Figure 3.2-18 shows TDS, SC and sulfate data from station L-1 between 1977 and 1994. The slight increase since 1979 for each of these analytes shows the surface water to have been slightly impacted by the mining operation although water quality at the point is of generally good quality. Since 1977, no cyanide has been detected at station L-1 and the pH of the water has remained neutral.

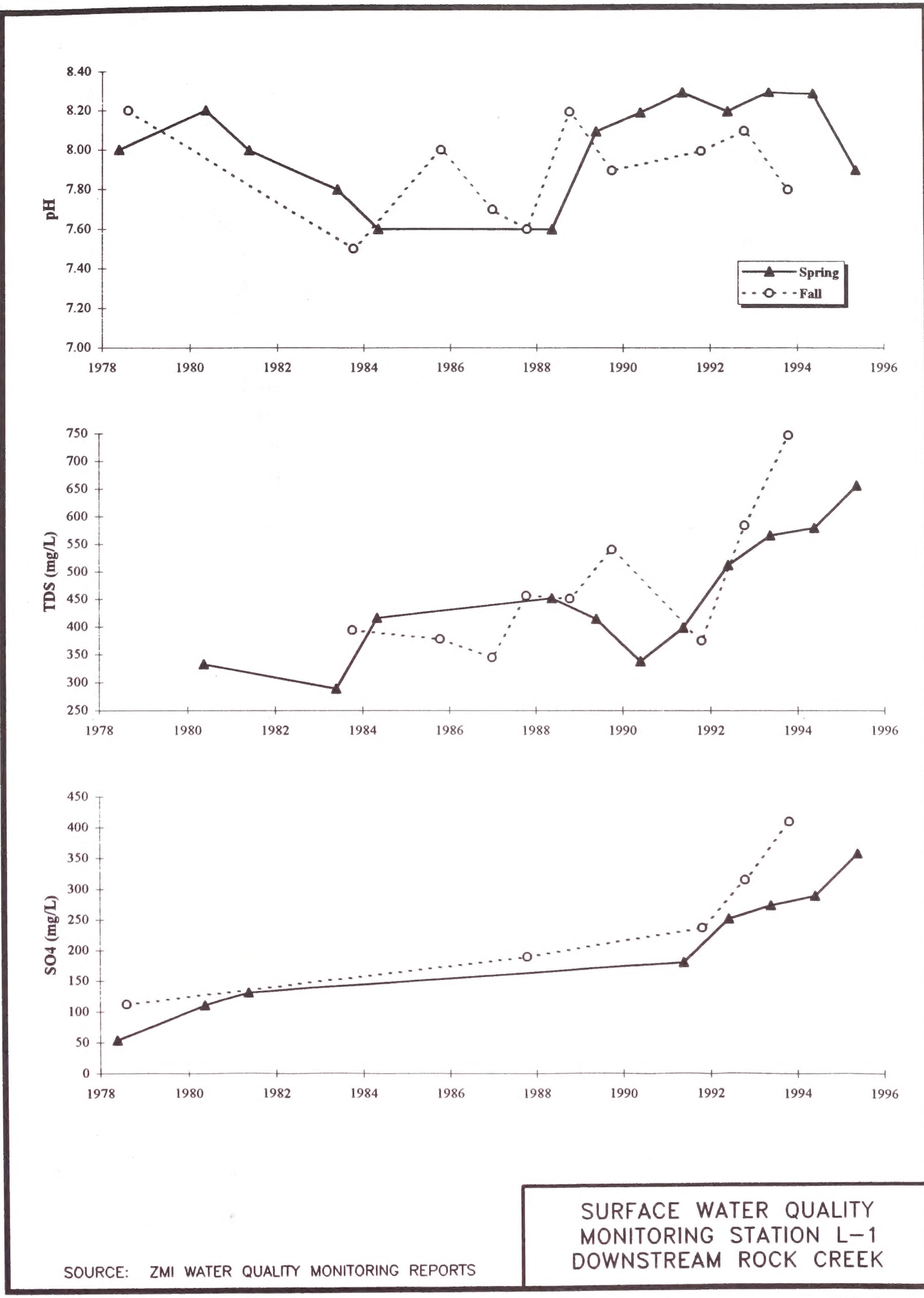
Mill Gulch. Surface water monitoring stations reviewed for Mill Gulch included L-18 and L-24 (Upper Mill Gulch, covered during 1988 by the construction of Mill Gulch waste rock repository), L-8 (western tributary to Mill Gulch draining the Landusky process area), and L-26 and L-25 (in a downstream direction). Stations L-25 and L-26 were replaced in 1994 by stations L-35 and L-36. Also reviewed were data from monitoring stations L-22 (half way down the Mill Gulch drainage) and L-7 (just above the Mill Gulch confluence with Rock Creek). Table 3.2-18 summarizes the water quality record for the total length of the Gulch with data from monitoring stations L-18, L-8 and L-7.

The record shows that the construction of the 1987 (Mill Gulch) leach pad had an immediate impact on the surface water quality downstream, monitored at that time by station L-18. Between 1987 and 1988 surface water samples taken at L-18 showed a decrease in pH from 7.1 to 3.2 combined with increases in sulfate concentrations from 12 to 268 mg/l, SC from 45 to 855

TABLE 3.2-17
ROCK CREEK SURFACE WATER QUALITY SUMMARY

	BASELINE		OPERATIONAL(BUT REPRESENTATIVEOF BASELINE)		OPERATIONAL(POST 1979)			
	Downstream L-1 (1977-1978)		Upstream L-29 (1990-1995)		Upstream L-28 (1991-1992)		Downstream L-1 (1979-1994)	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of samples	3		16		9		35	
pH S.U.	8.00-8.20	8	7.0-7.7	7.31	2.7-3.9	3.0	7.4-8.4	7.91
SC μmhos/cm	395-609	521	60-384	237	724-10700	3095	367-970	645
TDS mg/l	NA		48-272	166	621-14700	3720	310-751	476
TSS mg/l	11-11	11	ND-60	15.8	0.5-135	63	ND-380	46
SO_4 mg/l	53-112	82	14-129	64.2	340-9960	2412	71-410	220
CN mg/l	ND		ND-0.009	0.003	0.003-0.009	0.005	ND-0.013	0.003
NO_2/NO_3 mg/l	ND		ND-0.1	0.036	0.87-4.80	2.3	0.025-0.910	0.40
NH_3 mg/l	NA		ND		0.05-1.10	0.4	ND	
Hardness as CaCO3 mg/l	NA		29-185	111	205-1650	583	198-526	352
Ca mg/l	NA		7-51	29.2	53-306	125	56-145	104
Mg mg/l	NA		3-14	8.0	18-216	66	14-40	25.8
K mg/l	NA		1-3	2.42	2-20	5.7	2-4	3.05
Na mg/l	NA		2-8	5.0	8-1650	283	8-16	12.6
Cl mg/l	NA		ND-3.0	0.708	1-85	16	0.5-6.0	2.33
HCO_3 mg/l	NA		17-129	57.5	ND		121-228	172
Al mg/l	NA		(trc) ND-2.8	0.689	(trc) 38-679	261	(trc) ND-2.30	0.69
As mg/l	NA		(trc) ND-0.007	0.004	(trc) 0.03-5.51	2.3	(trc) 0.0025-0.8200	0.088
Cd mg/l	NA		(trc) ND-0.001	0.005	(trc) 0.07-0.60	0.3	(trc) ND-0.005	0.0022
Cu mg/l	NA		(trc) ND		(trc)0.18-2.34	0.92	(trc)ND-0.2	0.0083
Fe mg/l	NA		(trc) ND-2.52	0.648	(trc) 28-536	223	(trc) 0.01-5.77	1.60
Pb mg/l	NA		(trc) ND		(trc) ND-0.06	0.02	(trc) ND-0.02	0.0092
Mn mg/l	NA		(trc) ND-0.01	0.0083	(trc) 4.5-110.0	47	(trc) 0.03-0.35	0.131
Zn mg/l	NA		(trc) 0.01-0.1	0.047	(trc) 2.5-25.4	10.7	(trc) 0.02-0.73	0.205

NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated
(tot) = Total
(trc) = Total Recoverable



SURFACE WATER QUALITY
MONITORING STATION L-1
DOWNSTREAM ROCK CREEK

FIG. 3.2-18

TABLE 3.2-18
MILL GULCH SURFACE WATER QUALITY SUMMARY

	OPERATIONAL THROUGH 1986 (REPRESENTATIVE OF BASELINE)						OPERATIONAL 1987 THROUGH 1995					
	Upstream L-18 (1983-1986)		Midstream Tributary L-8 (1983-1986)		Downstream L-7 (1982-1986)		Upstream L-18 (1987-1988)		Midstream Tributary L-8 (1987-1995)		Downstream L-7 (1987-1995)	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of samples	4		3		10		2		15		26	
pH S.U.	6.8-7.1	6.97	NA		7.4-8.2	7.75	3.2-4.9	4.05	7.6-8.5	7.9	7.1-8.6	7.99
SC μmhos/cm	45-356	158	NA		113-527	322	316-855	585.5	580-1,260	1,001	187-1,470	788
TDS mg/l	84-232	136	NA		100-328	230	243-469	356	376-855	652	170-1,300	593
TSS mg/l	ND-10	4.5	NA		1370-1370	1370	14.0-14.0	14.0	ND-184	38.4	ND-73	7.63
SO_4 mg/l	8-112	44	NA		16-16	16	268-268	268	165-253	206	22-778	308
CN mg/l	ND		NA		ND-0.015	0.008	ND		0.01-0.118	0.05	ND	
NO_2+NO_3 mg/l	ND		NA		0.07-0.07	0.07	17.2-17.2	17.2	ND-5.73	2.38	ND-7.89	1.54
NH_3 mg/l	NA		NA		NA		NA		ND		ND	
Hardness as $CaCO_3$ mg/l	17-175	75	NA		63-286	174	112-208	160	112-769	489	90-890	445
Ca mg/l	4-8	6	NA		15-15	15	58-58	58	140-176	154	26-221	115
Mg mg/l	2-11	5.3	NA		6-6	6	15-15	15	25-37	30.1	6-82	41
K mg/l	2-2	2	NA		7-7	7	3-3	3	3.0-5.0	3.57	2-6	3.63
Na mg/l	2-10	5	NA		4-4	4	10-10	10	20-34	24.0	4-23	12.2
Cl mg/l	1-4	2	NA		5-5	5	2-2	2	15-71	45.3	0.5-10.0	4.34
HCO_3 mg/l	24-24	24	NA		55-55	55	ND		296-374	326	84-292	176
Al mg/l	NA		NA		NA		NA		NA		ND	
As mg/l	NA		NA		NA		NA		NA		NA	
Cd mg/l	NA		NA		NA		NA		NA		NA	
Cu mg/l	NA		NA		NA		NA		NA		NA	
Fe mg/l	1.28-1.28	1.28	NA		NA		NA		NA		NA	
Pb mg/l	NA		NA		NA		NA		NA		NA	
Mn mg/l	NA		NA		NA		NA		NA		NA	
Zn mg/l	0.13-0.13	0.13	NA		NA		NA		NA		NA	

Note: No pre-1979 (baseline data) available
NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated
(tot) = Total
(trc) = Total Recoverable

μmhos/cm and TDS from 84 to 469 mg/l. These changes in water chemistry were also observed at L-24. No cyanide was detected at L-18 or L-24 between 1983 and 1988, after which time the stations were covered by construction of Mill Gulch waste rock dump.

Monitoring station L-25 was located immediately downstream of the Mill Gulch waste rock dump, and has a record of only minimal ARD effects up until 1991 when the pH dropped to 4.3 and maximum concentrations of 926 mg/l sulfate, 540 mg/l TDS and 1420 μmhos/cm SC were reached. However, during 1991 and 1992 surface water quality below the waste rock dump improved substantially. Replacement station Z-35 is now located at the base of the Mill Gulch waste rock dump and in the sample taken during the spring of 1995 had a pH of 4.9, SC of 2,150 μmhos/cm, sulfate concentration of 1,540 mg/l and elevated levels of metals. The water draining from the waste rock dump is currently being captured in a contingency pond and recirculated onto the 87 leach pad. Recirculated flows from Mill Gulch average 40 gpm.

Monitoring station L-8 is located in a western tributary to Mill Gulch draining the Landusky processing plant and ponds. Station L-8 has reported detectable total and WAD cyanide in nearly every sample taken between 1983 and 1995, with a maximum of 0.12 mg/l (tot) in the spring of 1993. Concentrations of other analytes have been erratic over this time, although the pH of the surface water has remained near neutral in all samples (Table 3.2-18). The consistent cyanide detections and neutral pH indicate that the contamination has come from several spill events or a process pond leak in the Landusky process plant area.

Effects of mining activity are seen throughout the length of the gulch. Figure 3.2-19 shows a slight decline in water quality between 1982 and 1992 at monitoring station L-7 at the bottom of the Mill Gulch near its confluence with Rock Creek. This decline is illustrated by increasing TDS and sulfate, but relatively stable near-neutral pH. Also, metal concentrations at station L-7 are almost entirely below detection limits, indicating that the ARD-impacted waters originating in the headwaters of the drainage are being effectively neutralized by the time they get to the lower reaches of Mill Gulch.

<u>Montana Gulch</u>. Surface water monitoring locations reviewed in Montana Gulch included L-17 (immediately downstream of the 85/86 pad), L-16 (approximately 400 feet downstream), L-3 (the Gold Bug Adit [GBA] discharge), L-11 and L-12 (tributary to Montana Gulch, below 83 Pad) and L-2 (just upstream of the Montana Gulch, Rock Creek confluence).

Table 3.2-19 summarizes pre-1979 (baseline) and operational water data from station L-3 and L-2 downstream.

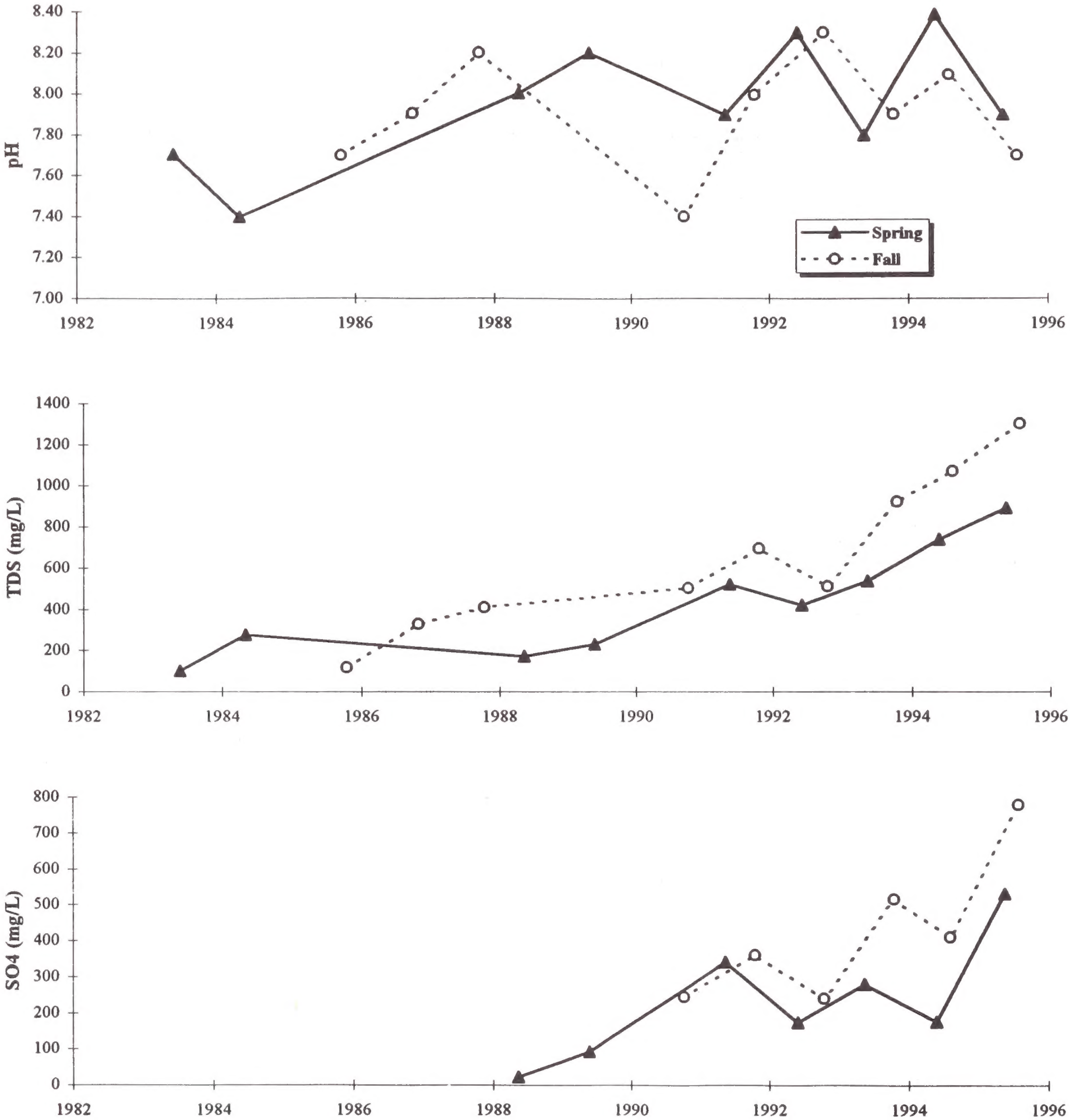
Station L-3 is actually groundwater; however, since it contributes the majority of the surface water flow in Montana Gulch and has a significant impact on the surface water quality downstream, it is treated as surface water for this discussion. Prior to 1979, L-3 had an average pH of 6.57, sulfate of 162 mg/l and SC of 503 μmhos/cm. Since 1979, water quality deriving from the GBA has been slightly reduced as illustrated by the slight increases in TDS and sulfate shown on Figure 3.2-20. In the spring of 1995, L-3 had a pH of 6.2, a SC of 699 μmhos/cm and a sulfate concentration of 294 mg/l. Water quality changes between 1979 and 1995 are shown on Figure 3.2-20. Water discharging from the adit has elevated iron concentration on average 14.25 mg/l since 1977. The iron rich water is currently being captured at the base of the 85/86 pad, and oxygenated causing the iron to precipitate out of solution.

Prior to 1979, the GBA discharged approximately 300 gpm. The majority of the discharge from the GBA is presently captured and used for road wetting.

Monitoring station L-17, located immediately below the 85/86 leach pad, has detected trace WAD cyanide in samples taken during 1986, 87, 88, 89, 91 and 92. The post 1986 detections are the result of a rupture in the 86 leach pad, identified and repaired during 1986. The 1992 detections are likely to be associated with a pipeline rupture directly below the 83 leach pad during 1992. Station L-17 also shows moderate impacts from ARD since monitoring began in 1983 reaching maximums of 1,370 μmhos/cm SC, and 721 mg/l sulfate during the winter of 1995 although the pH has remained neutral throughout this time.

Stations L-12 and L-13 are at the heads of two minor tributaries together draining the 83 leach pad. Surface water quality in both the tributaries appears to have been adversely affected by construction of the leach pads, with pHs falling to less than 3.0. TDS and sulfate levels recorded at station L-12 reached maximums of 84,800 mg/l and 64,100 mg/l, respectively during 1984. A significant improvement in water quality occurred between 1984 and 1990, restoring the pH to 7.6 and reducing the SC to 4,220 μmhos/cm. No data are available since 1990 because the stations have been dry. A similar trend is seen at L-11, although the maximum concentrations reached were considerably lower.

Limited pre-1979 (baseline) data exist from station L-2, (upstream of the Montana Gulch/Rock Creek



SOURCE: ZMI WATER QUALITY MONITORING REPORTS

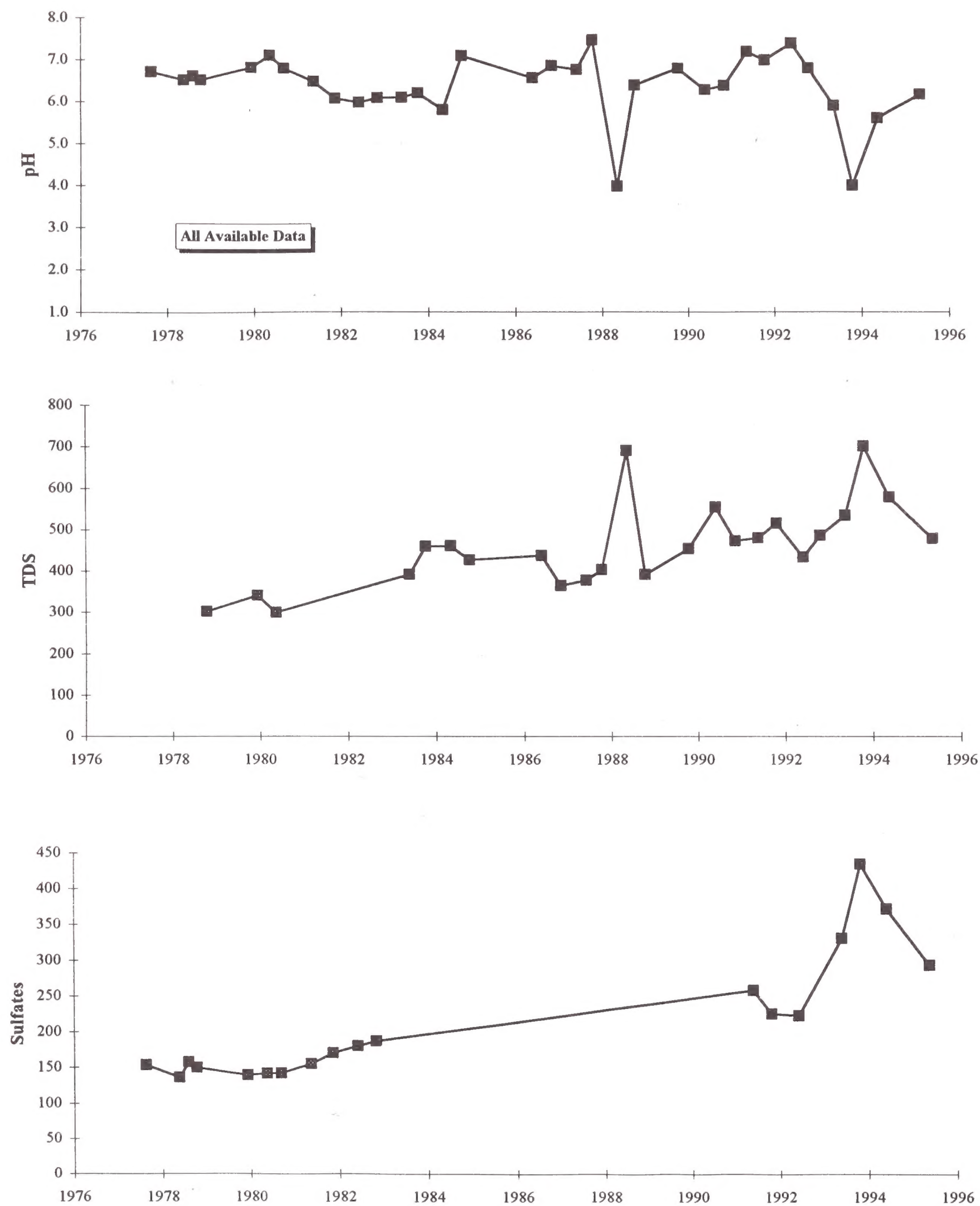
SURFACE WATER QUALITY
MONITORING STATION L-7
DOWNSTREAM MILL GULCH

FIG. 3.2-19

TABLE 3.2-19
MONTANA GULCH SURFACE WATER QUALITY SUMMARY

	BASELINE			OPERATIONAL			
	L-3 Upstream (Gold Bug Adit) (1977-1978)		L-2 Downstream (1978)	Gold Bug Adit L-3 Upstream (1979-1995)		L-2 Downstream (1979-1995)	
	Range	$\bar{x}$		Range	$\bar{x}$	Range	$\bar{x}$
No. of samples	6		1	28		37	
pH S.U.	6.50-6.70	6.57	8.40	4-7.50	6.39	6.50-8.40	7.73
SC µmhos/cm	485-520	503	330	430-901	595	242-1,090	676
TDS mg/l	302-302	302	NA	340-699	465	285-894	533
TSS mg/l			NA	20-287	70.5	2-3,550	194
SO_4 mg/l	150-186	161.80	61	140-435	223	45-572	276
CN mg/l	ND		ND	ND-0.14	0.0033	ND-0.13	0.01
NO_2/NO_3 mg/l	NA		NA	ND-0.17	0.04	ND-3.03	0.72
NH_3 mg/l	NA		NA	ND		ND	
Hardness as CaCO3 mg/l	NA		NA	217-413	295	127-596	373
Ca mg/l	62-63	62.50	NA	63-119	82.6	34-161	103
Mg mg/l	16-18	17	NA	11-28	18.4	10-47	27.4
K mg/l	3-3	3	NA	3-5	3.38	2-4	3.11
Na mg/l	13-16	14.50	NA	12-17	13.92	6-18	14.6
Cl mg/l	3.20-4	3.60	NA	ND-6	1.21	0.50-10.00	1.79
HCO_3 mg/l	98-104	101	NA	ND-120	76.4	50-192	118
Al mg/l	NA		NA	(trc) 1.0-2.2	1.63	NA	
As mg/l	0.179-0.19	0.18	0.11	(trc) 0.025-0.34	0.1936	(trc) 0.009-0.300	0.087
Cd mg/l	NA		NA	(trc) ND-0.006	0.0032	(trc) ND-0.01	0.0029
Cu mg/l	0.05	0.05	NA	(trc)ND-0.05	0.0200	(trc)ND-0.05	0.0132
Fe mg/l	11-11	11	NA	(trc) 3.26-28.5	14.25	(trc) 0.69-17.90	5.20
Pb mg/l	NA		NA	(trc) ND		(trc) ND-0.03	0.0084
Mn mg/l	NA		NA	(trc) 0.78-4.29	2.10	(trc) 0.02-1.12	0.3747
Zn mg/l	0.83-0.88	0.85	NA	0.61-3.51	1.56	(trc) 0.17-1.76	0.6377

NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated
(tot) = Total
(trc) = Total Recoverable



SOURCE: ZMI WATER QUALITY MONITORING REPORTS

SURFACE WATER QUALITY
MONITORING STATION L-3
(GOLD BUG ADIT DISCHARGE)
MONTANA GULCH

FIG. 3.2-20

confluence). Since 1979 no cyanide has been detected and pH values have remained near neutral. Figure 3.2-21 illustrates the slight increase that has been recorded in TDS and SC reaching maximums of 894 mg/l and 1090 μmhos/cm, respectively. Baseline sulfate concentration at L-2 was 146 mg/l; since 1979 sulfate concentrations have slowly increased to a maximum of 572 mg/l in the fall of 1993.

Swift Gulch/South Bighorn Creek. Two surface water monitoring stations exist within Swift Gulch (L-20 and L-21) and one in South Bighorn Creek (L-19); monitoring has been carried out at all three of these stations since 1985. Table 3.2-20 summarizes representative water quality data collected from station L-19 at South Bighorn Creek. Rising concentrations of sulfate and hardness and fluctuations in nitrate concentration at surface sites L-19 and L-20 show that drainage from the Landusky Mine site has affected water quality in Swift Gulch, which is a tributary to South Bighorn Creek.

King Creek. Studies of the historic tailing contained within the King Creek drainage and their potential impact on the water quality of the King Creek and lower drainages have been conducted in 1978 by the BLM, in 1979 by the Bureau of Indian Affairs (BIA), in 1982 and 1987 by the Council of Energy Resource Tribes (CERT), and in 1989 by the USGS. More recent investigations have been carried out by the Agency for Toxic Substances and Disease Registry (ATSDR) in January and July of 1993, and a Preliminary Assessment and Site Investigation report was also prepared during 1993 on behalf of the EPA Region VIII. The health consultations carried out by the ATSDR were in response to a request by the Indian Health Service (IHS) to determine if there was a health threat from the historic mine tailing to the people at Fort Belknap. Morrison Knudsen Corporation under contract to the EPA undertook investigations to assess the threat to human health and the environment and to determine the need for additional CERCLA/SARA or other action.

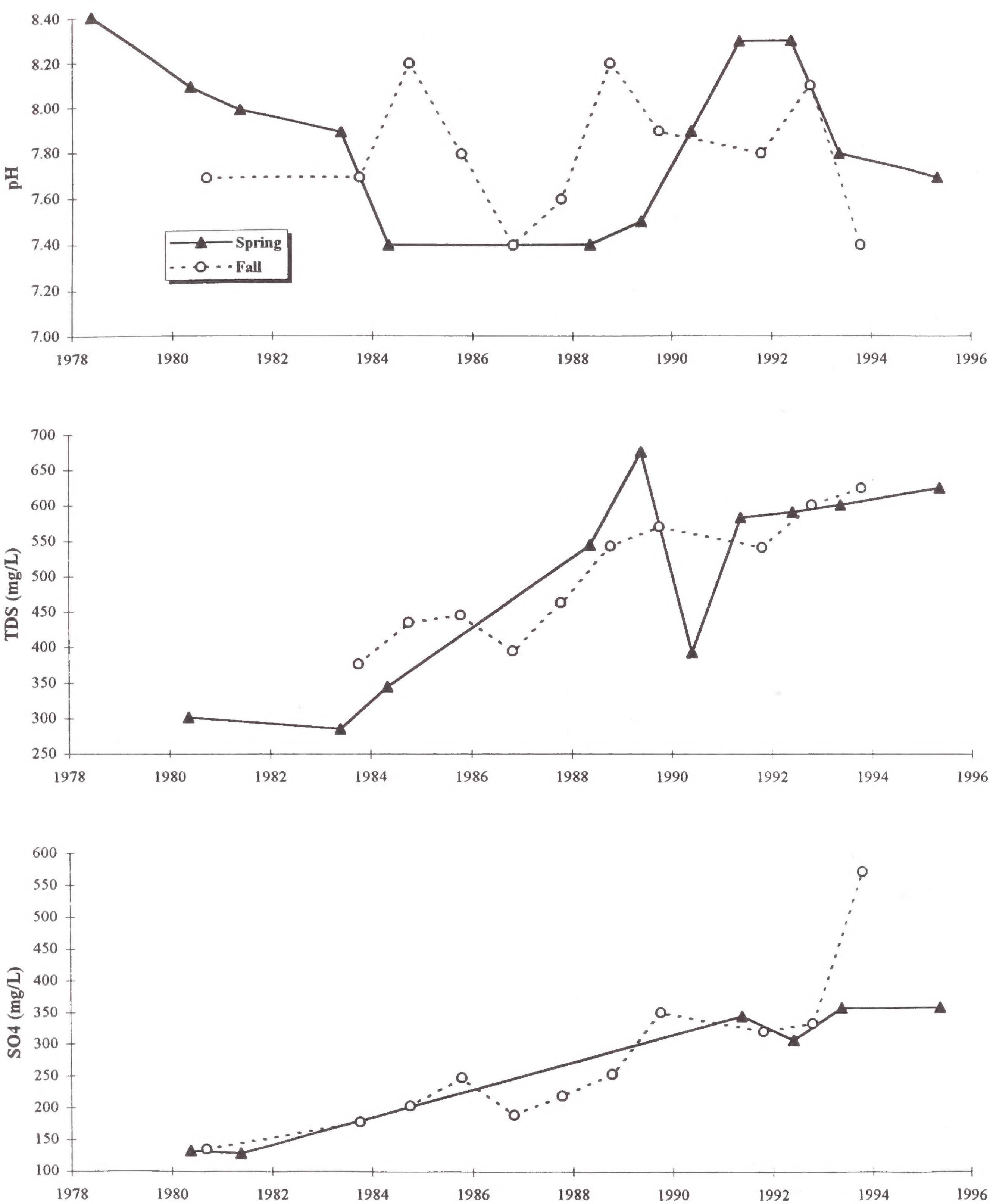
The ATSDR study concluded that concentrations of inorganic chemicals in the surface water and sediment from King Creek and Little Peoples Creek, do not represent a health risk to the people of the Fort Belknap Indian Reservation.

The surface water quality monitoring record is limited to two monitoring stations, L-5 and L-6 in the headwaters of King Creek. Data gathered at both stations are available from prior to and since 1979 are summarized on Table 3.2-20. Baseline or pre-Zortman mining activity data illustrate that the surface water was only slightly effected by mining activities if at all prior to 1979. In other words, if water in King Creek had been impacted by historic mining activity, the quality had essentially recovered by the time ZMI began large-scale mining. Sulfate concentrations ranging from 95 to 135 mg/l and SC from 490 to 525 μmhos/cm may have been due to drainage from adits at the head of King Creek, seepage from mine workings, and/or the mine tailing lining the creek bottom. Prior to 1979, the pH of the surface water ranged between 6.9 and 7.5. Sulfate concentrations ranging from 95 to 135 mg/l and SC from 490 to 525 μmhos/cm may have been due to drainage from adits at the head of King Creek, seepage from the pit complex, and/or the mine tailing lining the creek bottom. Prior to 1979, the pH of the surface water ranged between 6.9 and 7.5.

Figure 3.2-22 illustrates water quality trends at monitoring station L-5 between 1979 and 1995 with sulfate concentrations increasing from approximately 100 to 1,070 mg/l, TDS from 351 to 1,930, although a constant near neutral pH has been maintained throughout this period. Monitoring station L-5 has detected significant concentrations of nitrate in water samples since 1982 ranging between 7.37 and 36.9 mg/l. These nitrates are possibly derived from the fertilizers being used in the reclamation of the waste rock at the head of the drainage or ANFO used in blasting of waste rock and ore. Figure 3.2-23 illustrates water quality trends at station L-6 located approximately 4,000 feet downstream from L-5, showing significantly lower TDS and sulfate concentrations than observed at L-5, but higher levels of suspended solids. The high total suspended solids recorded in this stream represent the large amount of erosion that has occurred during major precipitation events. Of note is the reduction in TSS at this location after 1993, correlating with ZMI's efforts to remove the historic tailing from the drainage. Sulfate at L-6 reached a maximum concentration of 260 mg/l, TDS of 735 mg/l, and SC 838 μmhos/cm in 1993 and nitrates are generally below detection limits. The pH at this location has remained near neutral since monitoring began in 1987.

Summary of Landusky Surface Water Quality

In summary, the recent and historical surface water quality data reviewed for the Landusky mining area indicate the following:



SOURCE: ZMI WATER QUALITY MONITORING REPORTS

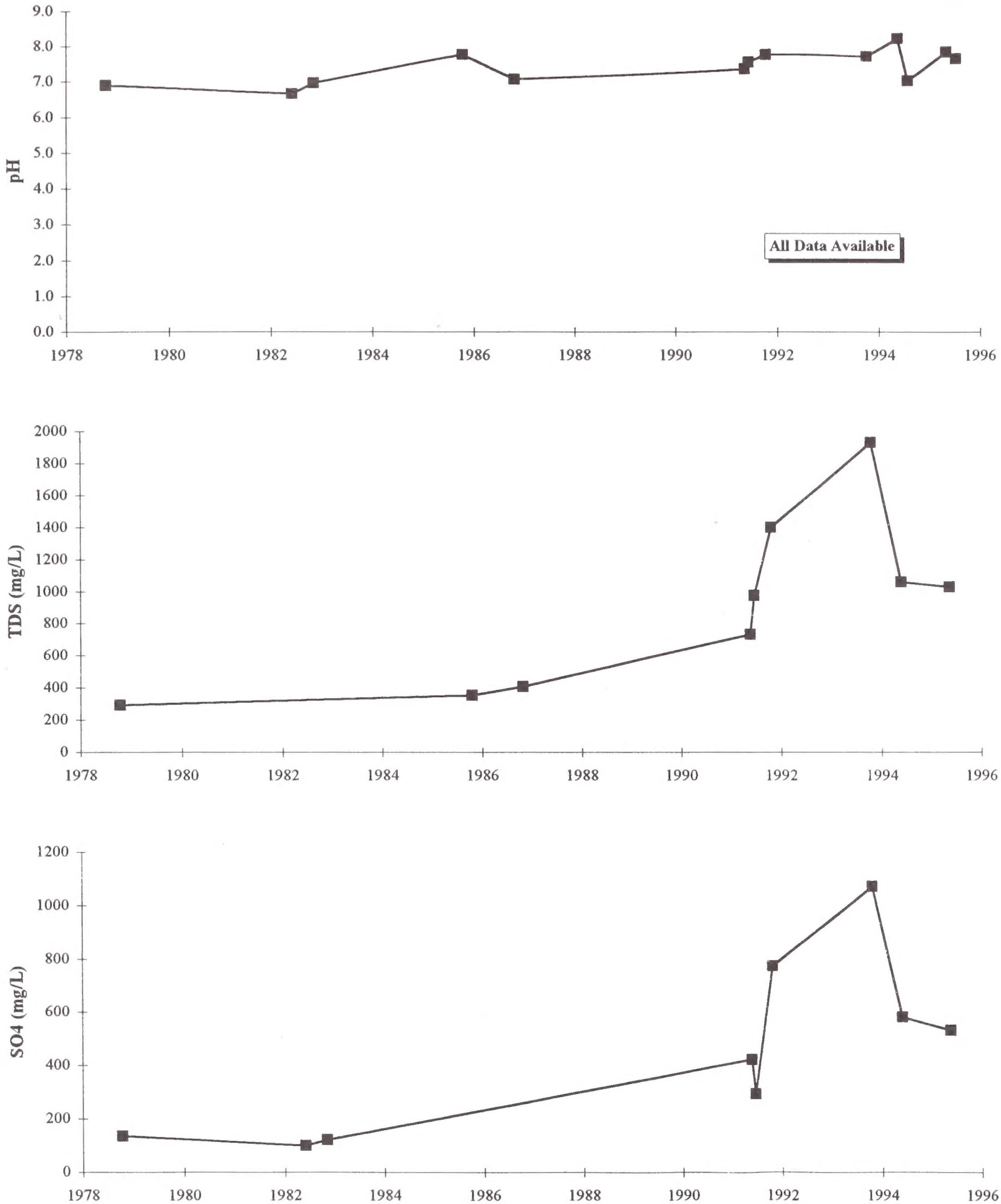
SURFACE WATER QUALITY
MONITORING STATION L-2
DOWNSTREAM MONTANA GULCH

FIG. 3.2-21

TABLE 3.2-20
KING CREEK/SWIFT GULCH
SURFACE WATER QUALITY SUMMARY

	BASELINE (Pre 1979)		OPERATIONAL (Post 1979)					
	L5	L6	L5 Upstream (1979-1994)		L6 Midstream (1979-1994)		Swift Gulch, L-19 (1985-1995)	
	Upstream	Downstream	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of Samples	1	1	31		22		37	
pH S.U.	6.9	7.5	6.7-8.3	7.52	7.2-8.1	7.70	6.4-8.0	7.39
SC μmhos/cm	490	525	340-2,010	1,175	293-838	606	48-593	324
TDS mg/l	291	306	351-1,930	986	236-735	401	53-419	228
TSS mg/l	NA	NA	ND-486	87.1	0.5-191.0	39.8	0.5-33.0	8.77
SO_4 mg/l	134	95	98-1,070	511	69-260	126	12-210	101
CN mg/l	NA	NA	ND		ND		ND	
NO_2/NO_3 mg/l	NA	NA	7.3-36.9	17.4	ND-1.29	0.27	ND-1.49	0.30
NH_3 mg/l	NA	NA	ND-0.1	0.05	ND		ND-0.10	0.053
Hardness as CaCO3 mg/l	231	245	168-1,330	629	153-486	336	18-266	152
Ca mg/l	70	77	53-368	207	49-136	88.6	4-73	41.9
Mg mg/l	14	13	9-99	46.9	8-40	26.8	2-20	10.3
K mg/l	2	2	2-6	4.13	2-5	2.94	1-4	2.45
Na	8	13	5-19	11.6	6-19	9.29	1-16	8.28
Cl mg/l	3	4	2-86	15.3	ND-3	1.35	ND-9.0	1.17
HCO_3 mg/l	122	207	80-204	168	100-408	270	(trc)13-113	64
Al mg/l	NA	NA	(trc)ND-0.02	0.13	(trc)ND-0.7	0.23	(trc)ND-1.0	0.29
As mg/l	NA	(trc) 0.01	(trc)ND-0.02	0.0069	(trc)ND-0.0170	0.0080	(trc)ND-0.024	0.013
Cd mg/l	NA	NA	(trc)ND-0.0010	0.0005	(trc)ND-0.0020	0.0005	(trc)ND-0.001	0.0005
Cu mg/l	NA	(trc)0.02	(trc)ND-0.011	0.0059	(trc)ND-0.01	0.0051	(trc)ND-0.003	0.0048
Fe mg/l	NA	(trc) 0.17	(trc)ND-1.47	0.165	(trc)0.01-1.47	0.46	(trc)ND-2.11	0.45
Pb mg/l	NA	NA	(trc)ND-0.05	0.014	(trc)ND-0.02	0.0063	(trc)ND-0.02	0.006
Mn mg/l	NA	NA	(trc)ND-0.15	0.040	(trc)ND-1.19	0.508	(trc)ND-0.08	0.0329
Zn mg/l	NA	NA	0.02-0.25	0.0629	(trc)ND-0.06	0.018	(trc)ND-0.16	0.09

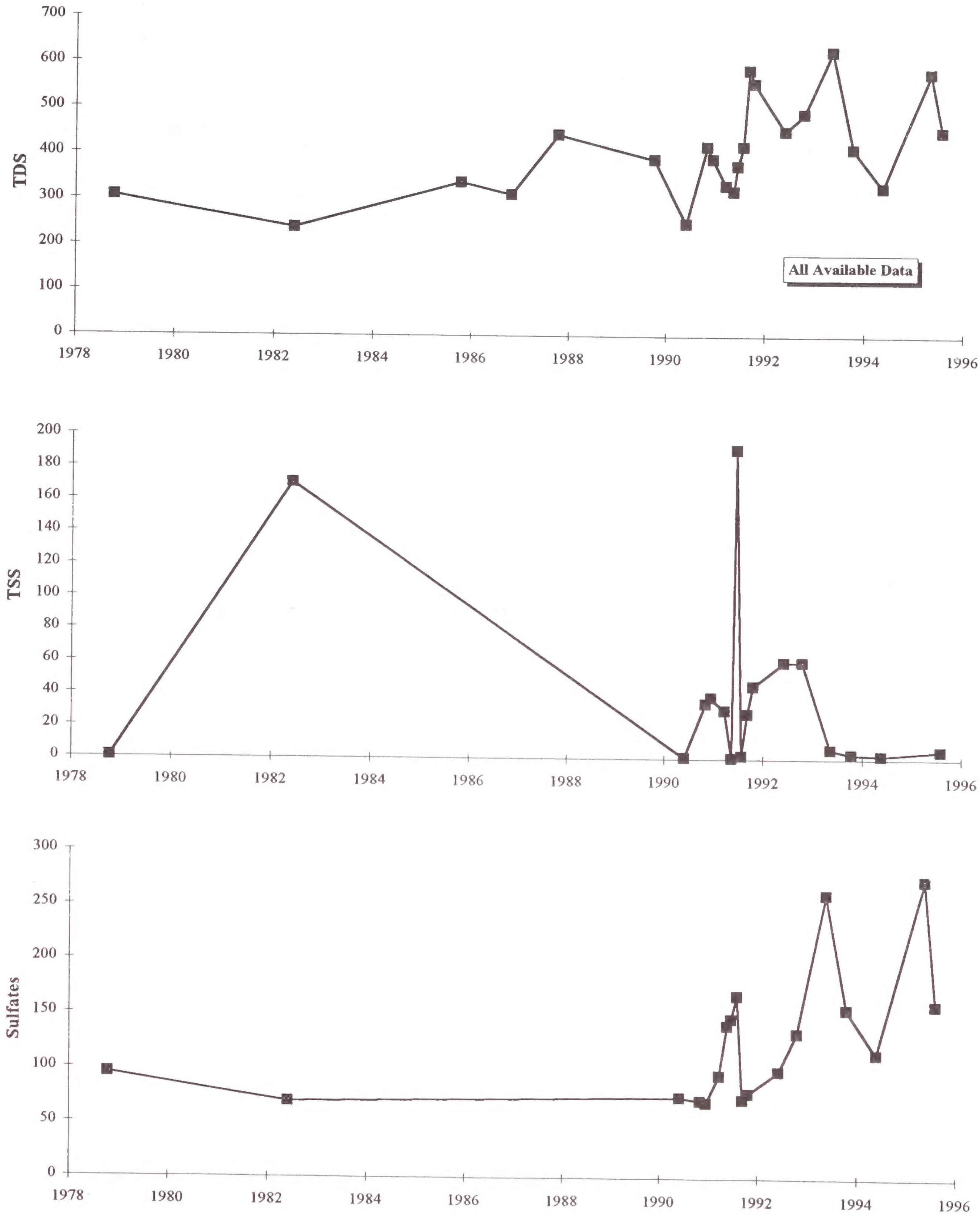
NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated
(tot) = Total
(trc) = Total Recoverable



SOURCE: ZMI WATER QUALITY MONITORING REPORTS

SURFACE WATER QUALITY
MONITORING STATION L-5
UPSTREAM KING CREEK

FIG. 3.2-22



SOURCE: ZMI WATER QUALITY MONITORING REPORTS

SURFACE WATER QUALITY
MONITORING STATION L-6
DOWNSTREAM KING CREEK

FIG. 3.2-23

Rock Creek/Sullivan Creek

- The 91 heap leach pad buttress and/or the underlying disturbed bedrock is contributing ARD to the surface water in Sullivan Creek drainage. However, what is not captured appears to be significantly diluted once reaching the confluence with Rock Creek.

- The upper reaches of Rock Creek above the confluence with Sullivan Creek may be representative of pre-Zortman mining activity baseline conditions. Pre-1979 (baseline data) are available from monitoring station L-1, the furthest downstream monitoring station. Between 1977 and 1978, station L-1 had an average pH of 8, sulfate concentration of 82 mg/l and SC of 521 μmhos/cm, indicating little or no adverse impact from historical mining operations.

- Effects from mining activity since 1979 are recognizable in the monitoring record of downstream monitoring station L-1, with minor increases in TDS and sulfate levels.

Mill Gulch

- Effects of mining activity are seen in surface water samples throughout the length of Mill Gulch, in the form of cyanide detections (from process plant spills or leaks), decreased pH and increased concentrations of dissolved solids. Two specific periods can be recognized in the sampling record having impacted surface water quality in Mill Gulch: (1) the construction of the 87 (Mill Gulch) heap leach pad and (2) high surface water flows during the spring of 1991 affecting the total length of the drainage.

- A western tributary to Mill Gulch draining the processing area and portions of the 83 leach pad complex contains traces of cyanide from past spills in the plant area.

- No pre-Zortman mining operation (baseline) data are available for Mill Gulch, but the earliest data gathered at L-7 in 1982 is representative of baseline surface water conditions for the drainage as the earliest disturbances were in 1985/1986 during preconstruction testing of the 87 leach pad site.

Montana Gulch

- Surface water quality data from prior to Zortman mining activity are available from monitoring station L-2 (downstream) and suggest that the upper reaches of the drainage were impacted by ARD prior to Zortman mining activities commencing in 1979. This impact was most likely derived from discharge from the August, Niseka, and Gold Bug drain adits. Station L-2 had an average pH of 7.74, sulfate concentration of 269 mg/l, TDS of 524 mg/l, and SC of 666 μmhos/cm.

- Water draining from the 83 Pad area is of poor quality although it appears to have improved substantially since 1984.

- The Gold Bug Adit has been contributing the bulk of flow in Montana Gulch since 1960. The iron rich, near neutral waters discharging from the adit are currently captured and oxygenated to precipitate the excessive iron out of solution.

South Bighorn Creek

- South Bighorn Creek surface water quality data, have shown rising sulfate and hardness concentrations since 1990, however, water quality has remained of good general quality.

King Creek

- Baseline data from station L-5 and L-6 indicate that King Creek surface water may have been slightly impacted by historic mining activities prior to 1979. Stations L-5 and L-6 had pHs of 6.9 and 7.5, sulfate concentrations of 134 and 95 mg/l, TDS of 291 and 306 mg/l, and SC of 490 and 525 μmhos/cm respectively in 1978.

- King Creek surface water quality has been progressively effected by mining activities at Landusky since 1979.

- Occasionally elevated levels of TSS reported in the King Creek monitoring record indicate that there has been significant erosion and or disturbances in the drainage. Action was taken by ZMI during 1993 to remove the historic tailing from the upper reaches of King Creek, has noticeably reduced the amount of suspended solids being transported downstream.

- The ATSDR study performed in January and July of 1993 concluded that concentrations of inorganic chemicals in the surface water and sediment from

King Creek and Little Peoples Creek do not represent a health risk to the people of the Fort Belknap Indian Reservation.

3.2.5.2 Groundwater Quality

Water quality data have been collected from a network of groundwater monitoring sites in the Zortman and Landusky mining areas on at least a bi-annual basis since 1977. This baseline monitoring effort has developed into a long-term sampling program at some sites, with the objective of detecting long-term changes in the water quality within and near the mining areas. Groundwater monitoring wells have been progressively completed in the representative alluvial and bedrock units since 1977 as the operations have developed and expanded into new drainages. The water resources monitoring program under existing operations is detailed in Alternative 1, Section 2.5.3.

As with surface waters, groundwater samples are analyzed by Energy Laboratories in Billings, Montana. For QA/QC, duplicate samples are often sent to other laboratories. Groundwater quality monitoring in the area has also been carried out by EPA, BLM, DHES, and USGS. Data are also available from a few wells installed in 1978 prior to Zortman mining activity as part of the 1979 EIS program.

Several gaps have been identified in the current groundwater monitoring network with some drainages having too few or no groundwater monitoring wells, resulting in an imperfect characterization of groundwater quality and hydrogeology in the vicinity of some mining related facilities and drainages. Also, many monitoring wells have poor completions (being exposed to more than one rock type or allowing recharge from surface water). However, there is adequate information available to characterize groundwater flow and quality so as to describe existing conditions, assess impacts, and evaluate alternatives or develop mitigation.

Figures 3.2-24 and 3.2-25 are piper trilinear plots of the major anion and cation concentrations in groundwater samples from Zortman and Landusky during the spring 1994 sampling event. Similar to the distribution seen for surface waters at Zortman and Landusky, the groundwaters are of a general calcium bicarbonate through sulfate type. A distribution of alluvial, metamorphic, volcanic, and limestone groundwaters is seen along the sulfate axis of the trilinear, depending on presence and degree of impact from ARD.

One discernable group is the Goslin Flats shale groundwater samples (Figure 3.2-24). Their moderately high sulfate content combined with a lack of calcium and excess of sodium and potassium plots them away from the other waters lower in sodium and potassium.

Baseline Groundwater Quality

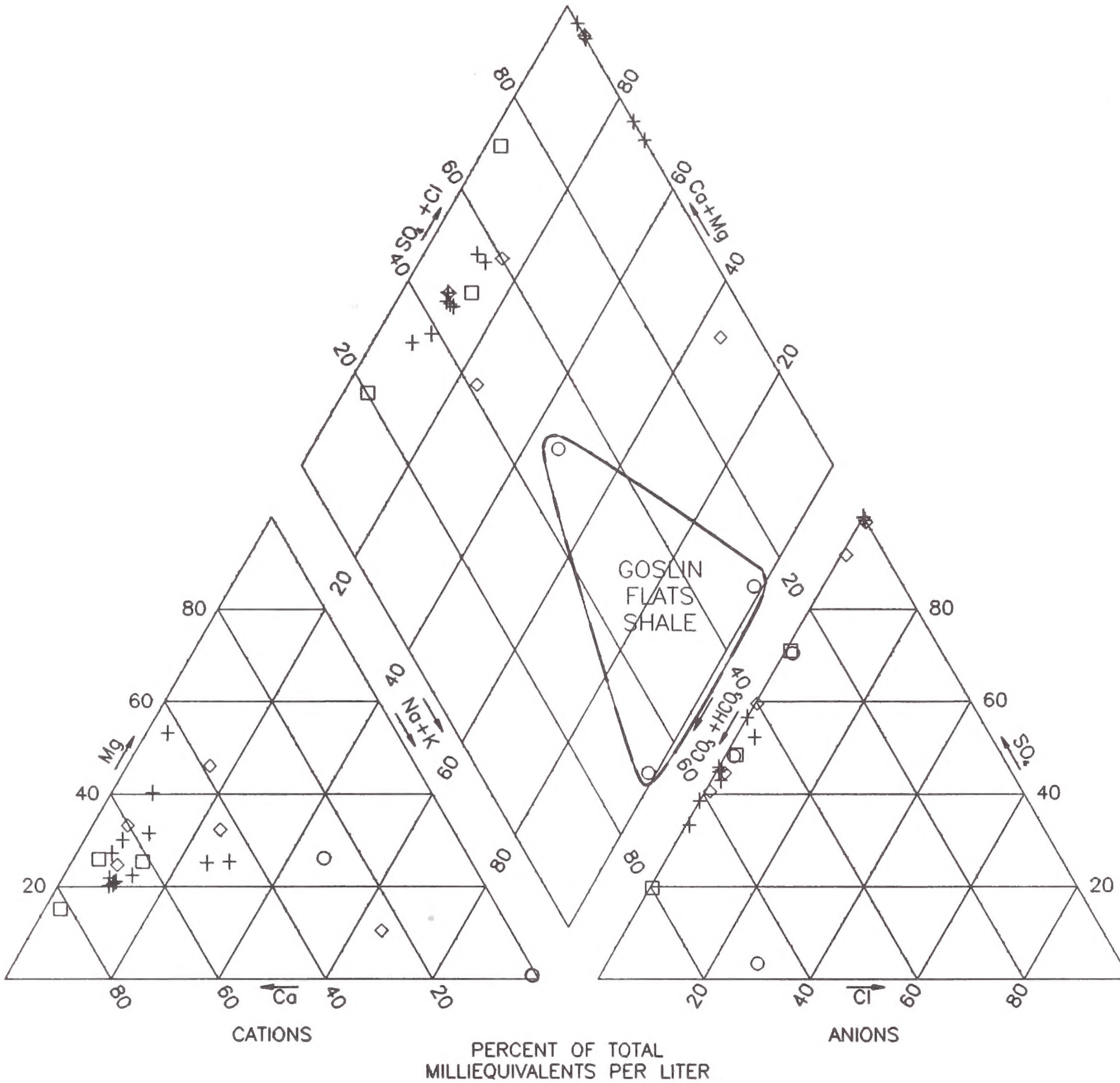
Table 3.2-21 summarizes all the available pre-1979 "baseline" groundwater quality data and summary statistics. For comparison purposes only, alluvial groundwater, bedrock groundwater, spring and adit discharges data have been pulled together to form a data set of baseline groundwater quality. The differences in chemistry between groundwater sources are recognized. In general the baseline groundwater quality data show the water to be of a general calcium bicarbonate type. Figures 3.2-24 and 3.2-25 illustrate that in many drainages the groundwater is now of calcium sulfate type. The higher proportion of sulfate coming from the ongoing oxidation of metal sulfides at the mine sites.

Zortman Area Groundwater Monitoring Results

The following summarizes these data in terms of impacts to groundwater quality due to past or current mining operations and baseline groundwater quality conditions in presently disturbed areas and that of proposed mine expansion areas. Water quality and groundwater level data from monitoring wells known to be constructed with screen in both alluvium and bedrock and those wells suspected of having an unsatisfactory seal between the alluvium and the underlying bedrock have been excluded from the groundwater quality review. The locations of groundwater monitoring wells at Zortman are shown on Exhibit 1 (EIS map pocket).

Ruby Gulch. Wells used to evaluate groundwater conditions in Ruby Gulch include ZL-200, ZL-201, 203 and ZL-207R (completed in syenite rock within the open pits), RG-99 (fractured metamorphics in the upper reaches of the drainage), ZL-102 and ZL-101A (within fractured metamorphics and alluvium, respectively next to the process plant), RG-108 and ZL-134 (syenite and metamorphics below the process plant area), RG-109 and ZL-143 (alluvium below the process plant area and above the town of Zortman, ZL-142 (limestone above the town of Zortman, and Z-8A (Zortman community well completed in limestone).

Table 3.2-22 summarizes the groundwater quality throughout the length of Ruby Gulch. Monitoring wells completed within the pits at Zortman (Zl-200, ZL-201, ZL-202, ZL-207R) show the effects of ARD with pHs generally below 4. The two samples taken from ZL-200 during 1993 had pH's of 2.5 and 2.7, SC of 10,100 and 5,130 μmhos/cm and sulfate concentrations of 15,800 and 5,300 mg/l.



LEGEND

◇ ALLUVIUM

+ METAMORPHIC & VOLCANIC ROCK

□ LIMESTONE

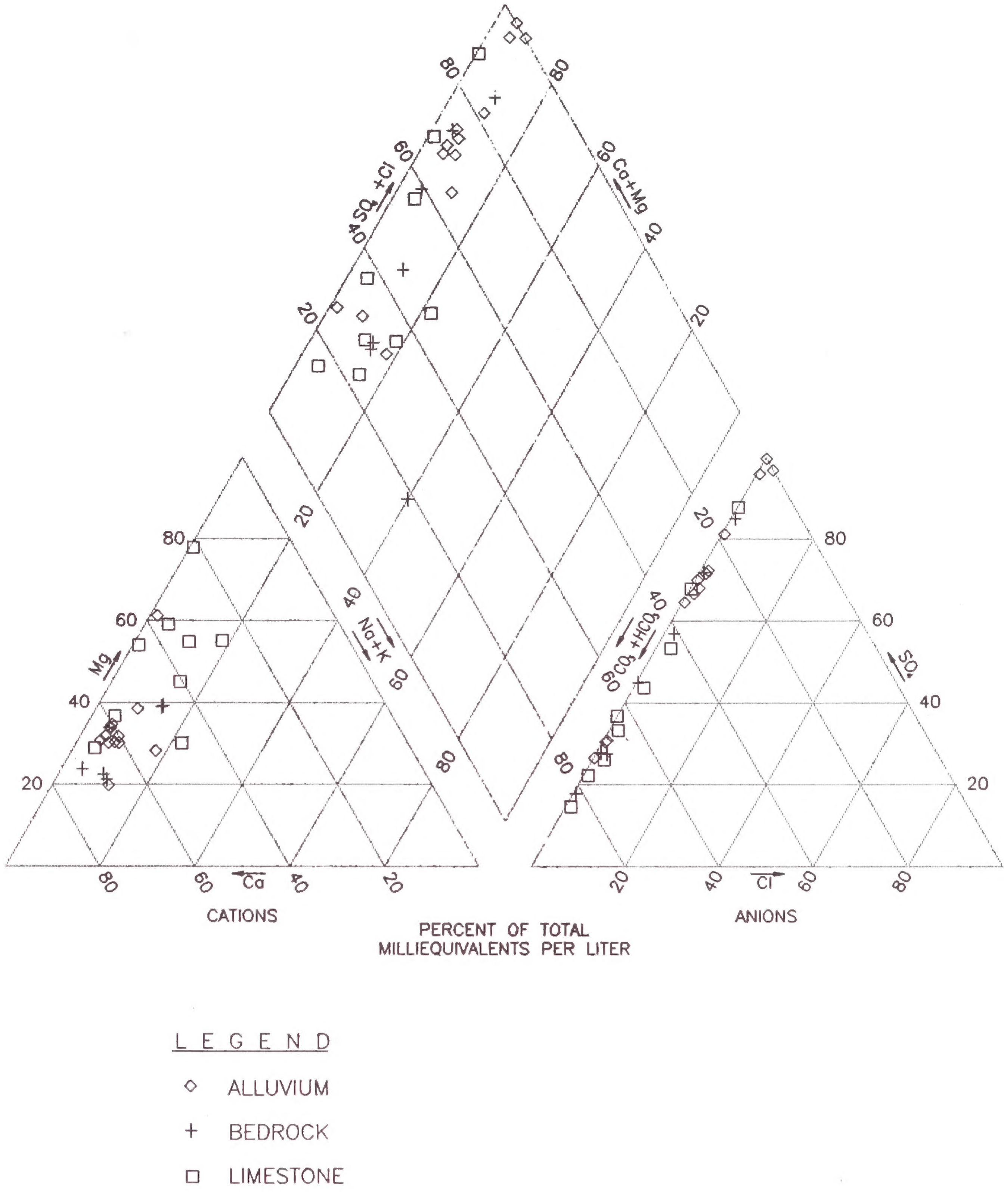
○ SHALE

SOURCE: ZMI WATER QUALITY MONITORING REPORTS

PIPER TRILINEAR PLOT
FOR ZORTMAN MINE
GROUNDWATER

ZORTGW

FIG. 3.2-24



SOURCE: ZMI WATER QUALITY MONITORING REPORTS

PIPER TRILINEAR PLOT FOR LANDUSKY MINE GROUNDWATER

LANDGW

FIG. 3.2-25

TABLE 3.2-21
GROUNDWATER BASELINE (PRE-1979) WATER QUALITY

	Zortman			Landusky										
	Ruby Gulch	Alder Gulch	Lodge Pole	Mill Gulch					Montana Gulch		King Creek	Summary Statistics		
	Spring @ Campground (1978)	Mine Adit Discharge (1978)	Developed Spring (1978)	Shallow Well No. 6 (1978)	Int Well No. B (1978)		Deep Well No. 1 (1978)		L-3 (Gold Bug Adit) Upstream (1977-1978)		Spring @ Tailings (1978)	Alluvial & Bedrock Groundwater		
No. of Samples	1	1	1	1	2		3		7		1			
					Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$		n	Minimum	Maximum
pH	7.8	7.2	8.0	7.4	7.8-8.0	7.9	7.4-7.6	7.5	6.5-6.7	6.6	6.9	13	6.5	8
Sc μmhos/cm	285	530	445	940	480-510	495	560-610	585	485-520	503	490	13	285	520
TDS mg/l	NA	NA	NA	NA	NA		NA		NA		NA	0		
TSS mg/l	<1.0	5	1	NA	5390		NA		22-32	27	<1.0	6	1	5390
SO_4 mg/l	8	100	5	10	2-12	7	15-44	29.5	150-186	161.8	134	11	2	186
Cn (tot) mg/l	NA	NA	NA	ND	ND		ND		0.00		NA	8	0	0.005
NO_2/NO_3 mg/l	NA	NA	NA	NA	NA		NA		NA		NA	0		
NH_3 mg/l	NA	NA	NA	NA	NA		NA		NA		NA	0		
Hardness as $CaCO_3$ mg/l	135	240	221	NA	NA		NA		NA		231	3	135	240
Ca mg/l	41	77	56	129	46		56		62-63	62.5	70	8	41	129
Mg mg/l	8	12	20	50	35		39		16-18	17	14	8	8	50
K mg/l	2	3	1	2	1		2		3-3	3	2	7	1	3
Na mg/l	5	16	2	5	2		2		13-16	14.5	8	8	2	16
Cl mg/l	4	5	3	6	4		4		3.2-4.0	3.6	3	7	3	6
HCO_3 mg/l	159	195	268	647	305		329		98-104	101	122	8	98	647
Al mg/l	NA	NA	NA	NA	NA		NA		NA		NA	0		
As mg/l	NA	0.108	NA	0.005	0.030		0.021		0.179-0.310	0.27	<0.003	7	0.005	0.31
Cd mg/l	NA	NA	NA	NA	NA		NA		NA		NA	0		
Fe mg/l	NA	2.3	NA	0.021	3.0		8.2		10.9-11	11	0.03	6	0.021	11
Pb mg/l	NA	NA	NA	NA	NA		NA		NA		NA	0		
Mn mg/l	NA	NA	NA	NA	NA		NA		NA		NA	0		
Zn mg/l	NA	0.8	NA	0.17	0.005		0.11-0.43	0.27	0.83-0.88	0.82	0.05	9	0.005	0.88

TABLE 3.2-22
RUBY GULCH GROUNDWATER QUALITY SUMMARY

	Representative Baseline				Operational				Operational			
	Bedrock				Bedrock				Alluvium			
	Metamorphics Upgradient RG-108 (1986-1995)		Metamorphics Downgradient ZL-134 (1989-1995)		Metamorphics Upgradient RG-99 (1984-1995)		Limestone Downgradient ZL-142 (1990-1995)		Tailings Upgradient RG-109 (1986-1995)		Gravels Downgradient ZL-143 (1990-1995)	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of Samples	32		14		15		18		32		15	
pH S.U.	7.00-7.90	7.60	7.20-7.80	7.60	2.60-4.20	3.03	6.50-7.60	7.22	2.70-4.70	3.46	7.50-7.90	7.67
SC μmhos/cm	367-587	450	384-425	403	141-9,990	4,460	982-1,990	1,398	755-4,480	1,895	1,120-1,300	1,196
TDS mg/L	244-421	306	225-289	257	106-20,200	6,812	829-1,800	1,241	569-5,587	2,015	954-1,150	1,084
SO_4 mg/L	85-192	104	68-80	76.0	2,680-6,290	4,643	377-1,070	670	384-3,100	1,286	569-658	621
CN mg/L	ND		ND		ND-0.009	0.004	ND-006	.0038	ND-0.24	0.035	ND-.005	.003
NO_2/NO_3 mg/L	ND-0.41	0.64	ND		2.70-3.60	3.67	0.81-3.77	1.78	0.27-4.40	1.46	0.92-0.92	0.92
NH_3 mg/L	ND		ND		0.3-1.0	0.55	ND		0.10-0.40	0.19	ND	
Hardness $CaCO_3$ mg/L	186-295	228	181-215	198	44-2,870	1,664	601-1,320	898	296-1,225	652	719-882	799
Ca mg/L	57-89	68	56-66	61.1	262-342	309	195-434	288	79-236	155	238-289	266
Mg mg/L	10-18	12.4	10-12	11.3	178-323	229	22-57	35.7	24-92	57.8	29-39	33
K mg/L	0.5-3.0	1.70	1-2	1.9	2-13	6.14	3-6	4.4	1-8	2.3	4-5	4.30
Na mg/L	7.0-12	9.0	8-10	9.0	6-29	12.4	6-12	8.9	11-22	15.8	7-9	8
Cl mg/L	ND-8	1.50	ND-7.00	2.07	0.50-45.00	11.9	2-12	4.7	2-18	8.0	2-4	3
HCO_3 mg/L	125-155	144	141-163	156	NA		129-228	180	ND		153-192	168
Al mg/L			ND		543-824	641	ND-3.40	0.60	15.20-261	76.9	ND	
As mg/L			0.06-0.14	0.11	0.50-1.2	0.87	ND		ND-0.049	0.009	ND	
Cd mg/L	ND-0.003	0.002	0.0001-0.0020	0.007	0.40-0.56	0.47	ND-0.003	0.0014	0.034-0.390	0.12	0.0003-.0003	.0003
Cu mg/L	ND		ND		29.5-43.5	34.9	ND		0.94-18.7	4.2622	0.06	0.06
Fe mg/L	0.20-1.22	0.60	0.36-0.9	0.6	3.10-346	120	ND		0.55-140.00	17.1	0.07-0.07	0.07
Pb mg/L	ND-0.01	0.005	ND-0.10	0.005	ND		ND		ND-0.03	0.01	ND	
Mn mg/L	0.27-0.71	0.48	0.23-0.37	0.27	53.8-72.2	63.1	ND-0.43	0.08	4.40-34.60	16.2	ND	
Zn mg/L	0.03-0.06	0.043	0.01-0.04	0.027	5.60-18	11.7	0.06-0.90	0.27	1.09-11.30	4.0	0.03-0.03	0.03

NA = Not Analyzed; ND = Not Detected; All concentrations dissolved unless otherwise stated
Note: No pre-1979 (baseline data) available

Review of groundwater quality data from RG-99 (metamorphic rocks at head of Ruby Gulch) shows a trend of increasing TDS, SC, hardness and decreasing pH. Operational data from well RG-99 reveal that the pH in the fall of 1984 was still high, but decreasing (from 8.2 down to 6.2). By the fall of 1985, the pH had dropped to between 5.1 to 5.6. Figure 3.2-26 illustrates that after 1989, the pH in well RG-99 ranged from 2.6 to 3.3; TDS values from 3,950 to 20,200 mg/l; and specific conductivity from 865 to 6,590 μmhos/cm. RG-99 also consistently detects elevated levels of iron, manganese, nickel and zinc. The elevated concentration of TDS, elevated sulfate and metals, and low pH indicate that the bedrock in the upper reaches of Ruby Gulch is impacted by ARD.

The pod of groundwater monitoring wells located just downstream of RG-99 show a variety of groundwater quality conditions. Wells RG-108 (63 feet deep within syenite porphyry) and ZL-134 (150 feet deep within syenite porphyry) show no effects from mining activity. The pH at RG-108 is generally near-neutral, with specific conductivities ranging from 367 to 587 μmhos/cm. Sulfate concentrations at RG-108 and ZL-134 average 104 and 76 mg/l, respectively, while TDS concentrations average 306 mg/l for RG-108 and 257 mg/l for ZL-134 (Table 3.2-22). Dissolved metal concentrations at these wells are consistently low.

Groundwater samples from ZL-102 (225 feet deep within fractured metamorphics) also appear to be relatively unaffected by mining activities with the exception of occasional cyanide detections. Monitoring well ZL-101A (78 feet deep in alluvium) had total cyanide concentrations detected in every sample between 1985 and 1988, with a maximum concentration of 0.10 mg/l. The effects of mining activity are also indicated by SC concentrations ranging from 1,100 and 1,800 μmhos/cm and TDS concentrations of 895 to 1,480 mg/l. The pH of the samples was slightly below neutral with an arithmetic mean of 6.8. Monitoring wells ZL-102 and ZL-101a are installed in the Zortman Mine processing plant area. The cyanide detections in the underlying groundwater probably resulting from process solution leaks and spills.

Monitoring well RG-109 is completed at a depth of 30 feet in mineralized tailing in Ruby Gulch downstream of the 85/86 leach pad. Groundwater flowing within the tailing is impacted by ARD, illustrated by low pH values (ranging from 2.7 to 4.70), elevated concentrations of TDS (from 569 to 5,587 mg/l), and sulfate from 384 to 3,100 mg/l. Water within the tailing also consistently has elevated concentrations of iron, manganese, nickel and zinc. It is not clear if this contamination is due to the tailing themselves or upstream ARD contamination, but baseline surface (pre-ZMI mining) surface water quality data from within the tailing was relatively good, suggesting upstream ARD may be the cause of the elevated metals.

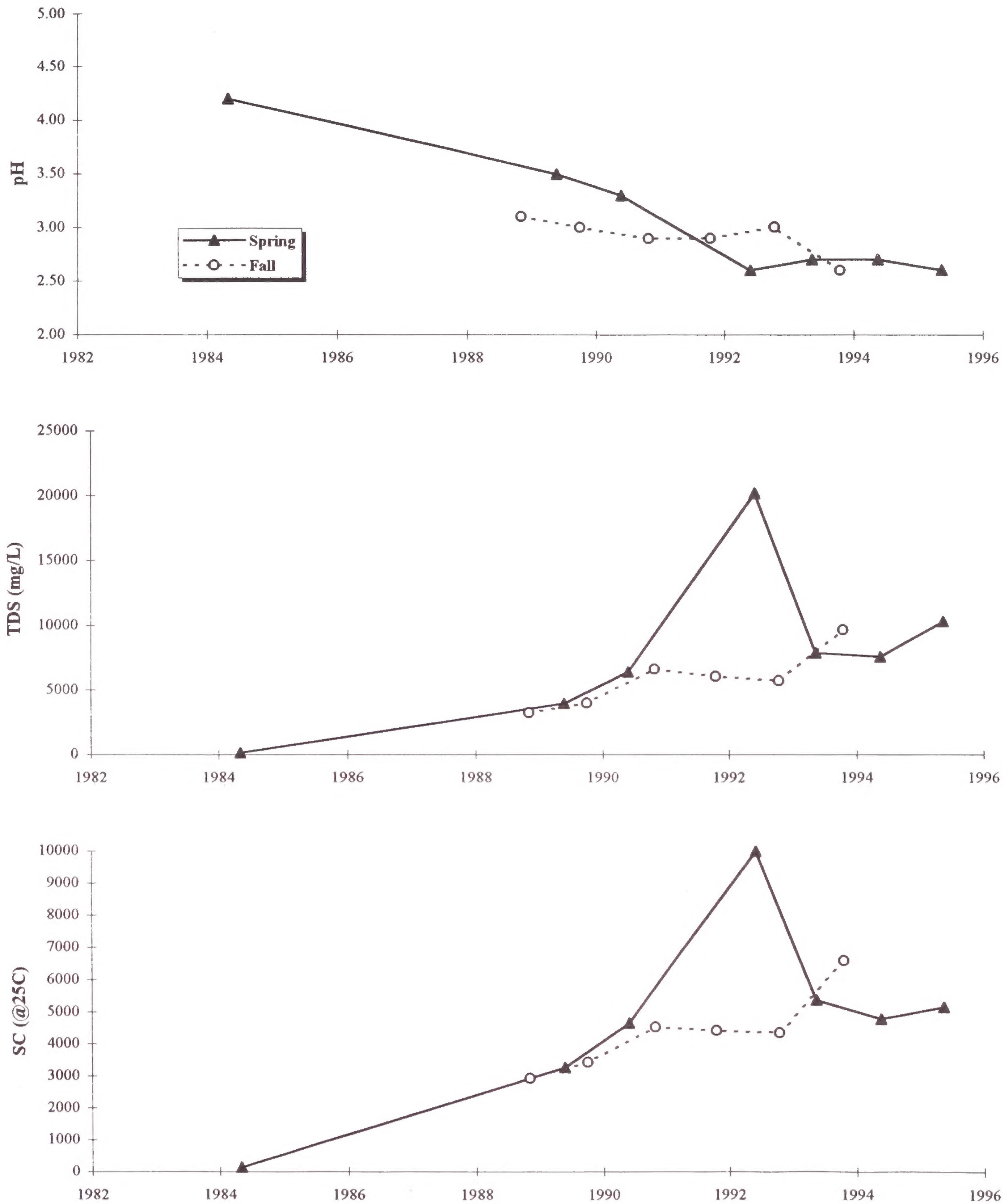
Monitoring well ZL-142 is completed in limestone bedrock (total depth 64 feet) at the town of Zortman. From 1990 through 1995, groundwater at this location had TDS concentrations averaging 1,241 mg/l and sulfate from 377 to 1,070 mg/l (Table 3.2-21). Metal concentrations within samples from ZL-142 are low or below detection limits, suggesting that the moderately elevated TDS and sulfate are probably due to neutralized ARD, or possibly naturally high sulfate conditions within the limestone. Water levels at this location indicate a downward vertical gradient, suggesting this water is currently recharging the limestone.

The Zortman community well Z-8A is located within an eastern tributary to Ruby Gulch and is completed with perforations between 395 and 738 feet in limestone bedrock. The well has been monitored since 1982 and has shown no indications of ARD contamination, with maximum concentrations of 438 μmhos/cm SC, 272 mg/l TDS and 46 mg/l sulfate. This tributary has no mining-related facilities within its drainage and is separated from the impacted limestone at ZL-142 by considerable distance and depth.

<u>Alder Gulch and Alder Spur</u>. Groundwater quality data from the Alder Gulch drainage area was reviewed from monitoring well ZL-107R (limestone, Carter Spur), ZL-110 (metamorphics in Alder Spur), AG-200 (syenite volcanics), AG-201 (limestone), AG-202 (alluvium) and AG-203 (limestone) from Alder Gulch in a downstream direction.

Table 3.2-23 summarizes alluvial and bedrock water quality data for the Alder Gulch drainage. Data are available for ZL-107R from 1982 to 1989. During this time the groundwater quality appears to have improved with TDS concentrations dropping from 747 to 306 mg/l. This improvement is likely due to the ongoing well development since the well was completed.

AG-200 is located just above the confluence of Alder Gulch and Alder Spur. The monitoring record from this bedrock well shows the groundwater to be of good general quality with an average TDS of 399 mg/l. However, samples taken during 1991 show a period of degradation, with the pH dropping to 6.5, TDS reaching a maximum of 1,170 mg/l and sulfate a maximum of 664 mg/l. Since 1991, the water quality has continued to improve.



SOURCE: ZMI WATER QUALITY MONITORING REPORTS

BEDROCK WATER QUALITY
MONITORING STATION RG-99
PORPHYRY METAMORPHIC ROCK
RUBY GULCH

FIG. 3.2-26

TABLE 3.2-23
ALDER GULCH GROUNDWATER QUALITY SUMMARY

	Operational									
	Bedrock								Alluvium	
	Upgradient Metamorphics (Alder Spur) (ZL-110) (1983-1995)		Metamorphics Carter Gulch Upgradient (ZL-107R) (1982-1989)		Upgradient AG-200 (1990-1995)		Downgradient Limestone AG-203 (1987-1995)		Downgradient AG-202 (1987-1995)	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of Samples	37		16		14		21		14	
pH S.U.	6.81-8.04	7.68	6.8-8.0	7.4	6.5-7.6	6.92	6.7-7.9	7.53	6.60-7.80	7.32
SC μmhos/cm	545-664	612	488-1030	654	245-1,170	523	199-892	473	199-1,450	562
TDS mg/l	422-550	384	306-747	423	147-1,080	399	132-729	325	132-1,300	435
SO_4 mg/l	75-127	107.8	258-318	288	60-664	226	40-411	166	40-793	244
CN mg/l	ND		ND		ND-0.006	0.0028	ND-0.02	0.006	ND-0.06	0.008
NO_2+NO_3 mg/l	ND-0.05	0.03	0.005-0.025	0.015	ND-0.57	0.13	ND-0.71	0.29	ND-1.19	0.37
NH_3 mg/l	ND		NA		ND		ND-ND		ND	
Hardness as CaCO3 mg/l	298-374	332	230-604	353	123-682	2.73	95-471	247	95-932	303
Ca mg/l	68-80	73.4	145-167	156	39-198	87.7	30-141	81.8	30-273	92.5
Mg mg/l	33-38	35.3	31-45	38	8-46	18.38	5-29	13	5-61	21.0
K mg/l	3-7	3.63	6-6	6	1-4	2.23	0.5-4	2.0	1-5	2.4
Na mg/l	10-14	11	11.00-17.00	14.00	4-15	8.0	3-7	5.7	4-16	8.0
Cl mg/l	ND-12	4.0	3.00-3.00	3.00	ND-3.00	2.04	2-25	4.9	2-9	4.6
HCO_3 mg/l	266-297	284	302-373	338	27-104	72.3	50-145	104	17-210	85.6
Al mg/l	ND		NA		ND-0.3	0.09	ND-0.20	0.06	ND-0.10	0.058
As/L	ND		0.01-0.01	0.01	ND		ND-0.022	0.009	ND-0.009	0.0036
Cd mg/l	ND		NA		ND-0.01	0.002	ND-0.004	0.0007	ND-0.002	0.0007
Cu mg/l	ND		ND-0.01	0.0075	ND		ND-0.02	0.006	ND-0.006	0.0051
Fe mg/l	ND-0.10	0.05	0.55-1.37	0.96	ND-1.02	0.13	ND-0.08	0.03	ND-0.04	0.02
Pb mg/l	ND-0.01	0.0067	ND-0.01	0.008	ND-0.01	0.005	ND-0.01	0.005	ND-0.02	0.009
Mn mg/l	0.05-0.07	0.06	0.05-0.07	0.06	ND-2.02	0.28	ND-0.06	0.01	ND-0.03	0.04
Zn mg/l	ND-0.48	0.13	0.04-0.61	0.33	ND-1.03	0.15	ND-0.73	0.13	ND-0.03	0.017

Note: No pre-1979 (baseline data) available
NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated

At well ZL-110 (200 feet deep in metamorphics and screened between 70 and 200 feet), specific conductivity has ranged from 545 to 664 μmhos/cm; pH from 6.81 to 8.04 units; and TDS from 422 to 550 mg/l (from 1983 to 1995). Sample analyses from this deep well show minimal or no effects from mining activities in contrast to surface water samples in the vicinity, and may be representative of baseline water quality in the bedrock of Alder Gulch.

Groundwater samples from the shallow alluvial well (AG-202) below the confluence of Alder Gulch and Alder Spur have a record of near-neutral pHs, occasional cyanide detections and variable SC, TDS and sulfate (Table 3.2-23). The cyanide detections may have resulted from emergency land application of processing solution during 1986-1987, which was carried out in cooperation with DSL and the BLM in response to extremely large precipitation events (Stephen 1993). No cyanide has been detected at AG-202 since 1992.

Monitoring wells AG-201 constructed in alluvium and limestone and AG-203 constructed in limestone only, are both located downstream of the main Alder Gulch/Alder Spur confluence. The monitoring record shows water from these wells to be of good quality with the exceptions of a period of degradation at AG-201 during 1986 with elevated TDS and sulfate concentrations and a maximum of 0.69 mg/l total cyanide and during 1991, when the pH dropped to 6.8, TDS reached 1,270 mg/l and sulfate 783 mg/l.

All monitoring wells within Alder Gulch, with the exception of the deep well ZL-110, had specific conductivity, sulfate, nitrate, and TDS values that were generally higher during July, September, and October of 1991 than in the remaining samples collected from these wells.

<u>Goslin Flats</u>. Groundwater quality data in Goslin Flats was reviewed from wells ZL-147 (alluvium, tributary to Goslin Flats), ZL-148 (undifferentiated shale, Goslin Flats), ZL-149 and ZL-154 (alluvium, Goslin Flats) and ZL-152 (undifferentiated shale, Goslin Flats).

Table 3.2-24 summarizes the alluvial and bedrock water quality for the Goslin Flats area. Wells in Goslin Flats that have elevated TDS and sulfate include ZL-147 and ZL-148 (completed in the shale). ZL-147 showed detectable levels of total and WAD cyanide during November 1991, but this detection is likely the result of a quality control error, as there is no source of cyanide in this area and no other detections of cyanide are recorded in nearby wells or surface water monitoring sites. The pH in this well has been constant and near neutral, but specific conductance and total dissolved solids analysis are relatively high, with average values of 1,280 μmhos/cm and 957 mg/l, respectively. Sulfate concentrations are also elevated, reaching a maximum of 480 mg/l.

The other alluvial groundwater monitoring well reviewed (ZL-149) is located downgradient at Goslin Flats. Water quality data from this well shows a near neutral pH, moderate SC ranging from 792 to 991 μmhos/cm, and TDS concentrations ranging from 545 to 663 mg/l. Sulfate concentrations are also lower than in the upgradient alluvium, ranging from 196 to 246 mg/l.

Bedrock monitoring well ZL-152 has no detections of cyanide and a pH with an arithmetic mean of 8.1; however, since installation in 1990, the SC and TDS in the well have fluctuated significantly, reaching maximums of 2,130 μmhos/cm and 1,380 mg/l, respectively. Sulfate in this deeper well has remained low with an average concentration of 41.1 mg/l. Monitoring well ZL-148 also has a slightly alkaline pH with an arithmetic mean of 8.3 and SC and TDS levels with mean values of 2,822 μmhos/cm and 1,887 mg/l, respectively. Sulfate concentrations at ZL-148 have fluctuated reaching a maximum concentration of 1,050 mg/l in the fall of 1993.

The consistently neutral pH's and varying sulfate concentrations suggest that the elevated dissolved constituents in the samples is due to continuing water/rock interaction within the mineral-rich shales.

<u>Lodgepole Creek.</u> Lodgepole Creek drains approximately 15 square miles of the northern portion of the Little Rocky Mountains, its headwaters starting just north of the present day Zortman Mine workings. Groundwater quality data in the Lodgepole drainage is limited to two newly completed wells in Glory Hole Gulch (ZL-209 and ZL-210) and a spring Z-6, located on the hillside above Lodgepole Creek north of the confluence with Glory Hole Creek. Lodgepole groundwater data are summarized on Table 3.2-25. Monitoring wells ZL-209 and ZL-210 are completed at 260 feet and 445 feet respectively, within igneous and metamorphic bedrock. The available sampling record from these groundwaters show little, if any, impact from mining in the immediate vicinity of the wells with pHs of 7.4 and 7.8, sulfate concentrations of 77 and 158 mg/l, and TDS from 228 to 389 mg/l. The monitoring record from spring Z-6 spans from 1979 to 1995 and shows the spring waters to be unimpacted by neighboring mining activities with a consistently neutral pH and average TDS and sulfate concentrations of 227 mg/l and 14 mg/l, respectively.

TABLE 3.2-24
GOSLIN FLATS GROUNDWATER QUALITY SUMMARY

	Representation of Baseline							
	Alluvium Upgradient ZL-147 (1990-1995)		Alluvium Downgradient ZL-149 (1990-1995)		Bedrock Upgradient ZL-152 (1990-1995)		Bedrock Downgradient ZL-148 (1990-1995)	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of Samples	17		17		17		17	
pH S.U.	7.00-7.90	7.60	7.40-8.10	7.80	7.5-8.4	8.1	7.5-8.7	8.30
SC μmhos/cm	1,080-1,340	1,280	792-991	918	621-2,130	1,170	2,270-3,150	2,822
TDS mg/l	831-999	957	545-663	605	426-1,380	730	1,660-2,050	1,887
SO_4 mg/l	410-480	452	196-246	220	27-51	41.1	86-1,050	977
CN mg/l	ND-0.031	0.045	ND		ND		ND	
NO_2/NO_3 mg/l	0.08-0.69	0.35	ND		ND-0.21	0.06	ND-1.68	0.17
NH_3 mg/l	ND		ND		0.30-0.70	0.51	1.30-3.30	1.98
Hardness as CaCO3 mg/l	623-710	676	363-454	412	6-53	19.1	15-178	43.8
Ca mg/l	116-128	121	81-104	94	ND-7	3.76	4-17	8.4
Mg mg/l	80-96	91	39-47	43	0.50-8.00	2.34	2-8	4.2
K mg/l	6-8	6.8	3-7	5.3	2-17	5.06	3-6	4.4
Na mg/l	50-61	54.2	54-63	57.6	165-515	284	574-764	674
Cl mg/l	2-5	3.43	3-5	4.2	18-267	92.5	10-53	26.0
HCO_3 mg/l	346-402	388	322-424	365	376-986	565	486-666	560
Al mg/l	ND-0.1	0.055	ND		ND-16.2	1.38	ND-0.3	0.14
As mg/l	ND		ND		ND-0.006	0.0028	ND-0.01	0.004
Cd mg/l	ND		ND		ND-0.001	0.0005	ND	
Cu mg/l	ND		ND		ND		ND-0.01	0.0055
Fe mg/l	ND-0.10	0.034	ND-0.06	0.020	ND-3.34	0.55	ND-0.37	0.1065
Pb mg/l	ND		ND-0.01	0.0058	ND		ND-0.02	0.0076
Mn mg/l	ND-0.22	0.03	ND-0.01	0.008	ND-0.04	0.018	ND-0.01	0.009
Zn mg/l	ND-0.02	0.014	ND-0.09	0.0338	ND-0.13	0.038	ND-0.08	0.028

Note: No pre-1979 (baseline data) available
NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated

TABLE 3.2-25
LODGEPOLE CREEK GROUNDWATER DATA

	Operational					
	Spring Water Upstream (Z-6) 1979-1995		Bedrock Upgradient (ZL-210) 1995		Bedrock Upgradient (ZL-209) 1995	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of Samples	41		3		4	
pH S.U.	7.1-8.4	8.02	7.4-7.8	7.6	6.5-7.8	7.43
SC μmhos/cm	310-455	406	474-523	503	330-373	355
TDS mg/l	187-292	227	294-389	335	228-259	243
SO_4 mg/l	11-26	14.0	112-158	128	76-80	77.3
CN (tot) mg/l	ND		<0.005		<0.005	
NO_2+NO_3 mg/l	ND-0.17	0.09	<0.05		<0.1	
NH_3 mg/l	ND		<0.05		<0.1	
Hardness as CaCO3 mg/l	213-278	245	246-271	255	129-168	156.5
Ca mg/l	46-61	56.4	73-81	76	42-44	43.3
Mg mg/l	21-27	24.9	16-17	16.3	14-15	14.5
K mg/l	ND-2.0	0.75	3-4	3.3	1.0-2.0	1.3
Na mg/l	ND-5.0	1.29	11-16	12.7	9.0-9.0	9.0
Cl mg/l	ND-8.0	0.98	<1		<1.0	
HCO_3 mg/l	252-288	272	151-154	152.3	124-129	127.3
Al mg/l	(trc) ND-0.40	0.07	<0.1		<0.1	
As mg/l	(trc) ND-0.005	0.0029	0.042-0.211	0.142	0.012-0.018	0.0123
Cd mg/l	(trc) ND		<0.001		<0.001	
Cu mg/l	(trc) ND		<0.01		<0.01	
Fe mg/l	(trc)/tot ND-0.99	0.1007	<0.03-0.73	0.495	ND-0.06	0.0313
Pb mg/l	(trc) ND-0.020	0.007	<0.01		<0.01	
Mn mg/l	(trc) ND-0.13	0.0161	0.40-0.54	0.477	0.10-0.10	0.10
Zn mg/l	(trc) ND-0.300	0.027	0.01-0.25	0.097	ND-0.04	0.063

ND = Not Detected

Note: Spring discharges from limestone bedrock.

Samples were taken by the EPA from the Lodgepole low income housing groundwater supply during 1990 and 1991. The drinking water was found to be of good general quality with no MCL exceedances.

Beaver Creek. Beaver Creek drains approximately 7.5 square miles of the eastern portion of the Little Rocky Mountains. No mining extensions are proposed to enter the Beaver Creek drainage and no groundwater quality data are presently available.

Summary of Zortman Area Groundwater Monitoring Results

In summary, the recent and historical groundwater quality data reviewed for the Zortman mining area indicate the following:

Ruby Gulch

- With the exception of RG-108 and possibly ZL-143, groundwater monitoring wells constructed in the metamorphics at the head of Ruby Gulch show effects of mining operations, including cyanide detections, depressed pHs, increased specific conductivity values, and increased concentrations of sulfate, TDS, and metals.

- Water quality data from wells RG-108 may represent baseline conditions for mineralized rocks in this area, as they appear to be isolated from any recognizable effects of ARD.

- Results from groundwater monitoring near the bottom of Ruby Gulch (ZL-142 in Madison Formation limestone near the Zortman townsite) show that by this point, much of the potential ARD has been neutralized, in the subsurface, although cyanide has been detected a number of times at trace concentrations in ZL-142 samples. Despite neutral pHs, specific conductivity and TDS values in these monitoring wells have remained high, suggesting that the water recharging the limestone is impacted by neutralized ARD.

Alder Gulch/Alder Spur

- There are no pre-1979 "baseline" data reported from groundwater wells in the area, but data from ZL-110 may be representative of baseline water quality for metamorphic bedrock in Alder Gulch.

- The shallow wells AG-200, AG-201, and AG-202 were first sampled in 1986 or 1987 and showed effects of mining activities at that time. These include cyanide detections, decreased or variable pH values, increased specific conductance values, and increased sulfate, TDS, and metals concentrations.

- Land application of treated process solution in 1986 and 1987 adversely affected the groundwater quality in all the shallow wells within Alder Gulch. These activities likely account for the increase in cyanide, sulfate, and other analytes in wells AG-200, AG-201, and AG-202, mentioned above.

- Limestone bedrock well ZL-107R, located at the head of Alder Gulch shows a linear improvement in groundwater quality from 1982 until the last sampling event at ZL-107R in 1989 (indicated by decreasing levels of SC, TDS and Hardness).

- With the exception of ZL-107R (not sampled) and ZL-110 (deep well), all other alluvial and bedrock wells within the Alder Gulch drainage suffered a period of degraded water quality during 1991, but have shown improving groundwater quality conditions since that time.

Goslin Flats

- Shallow alluvial and deeper wells completed in the underlying shale have relatively high TDS and sulfate concentrations which appear to be due to water/rock interaction with the mineral-rich shales.

- All Goslin Flats groundwater wells are unaffected by present mining operations and can be considered as baseline groundwater conditions for alluvium and shale bedrock in the Goslin Flats area.

Lodgepole Creek

- From the available groundwater quality data in Lodgepole Creek, it appears that there is little, if any, impact from mining activity.

Landusky Area Groundwater Monitoring Results

The locations of groundwater monitoring wells at Landusky are shown on Exhibit 2 (EIS map pocket).

Rock Creek/Sullivan Creek. Sullivan Creek, the upper tributary to Rock Creek, drains the 91 heap leach pad area (Sullivan Park). Groundwater quality data were reviewed from ZL-132 (alluvial well, Sullivan Creek), ZL-131 (volcanic bedrock well, Sullivan Creek), ZL-133 (limestone bedrock well, near the bottom of the Rock Creek Gulch), TP-1, TP-2 and TP-3 (alluvial wells at Landusky town) and TP-4 (a bedrock well at Landusky).

Groundwater quality data for Rock Creek are summarized on Table 3.2-26. Sampling of the alluvial monitoring well (ZL-132) downstream of the Sullivan Park dike shows sulfate and SC concentrations to have increased to 2,360 mg/l and 3,180 μmhos/cm respectively in the fall of 1993, and the pH of the water to be at 4.5 in 1995. Water samples from ZL-132 are also characterized by elevated levels of aluminum, manganese and zinc. These data indicate substantial effects on the alluvial groundwater from ARD most likely derived from the 91 leach pad dike or underlying acid-generating bedrock. Monitoring of well (ZL-131 bedrock well) suggests that the impacts have also reached the bedrock aquifer illustrated by a slight decrease in pH and increasing sulfate concentrations since 1992 reaching a minimum of 6.0 and a maximum of 806 mg/l, respectively (Table 3.2-26).

Groundwater quality at the base of Rock Creek and within the town of Landusky has been monitored by wells ZL-133 and TP-4 (Table 3.2-26). Well ZL-133 is completed in alluvium and limestone. Although no impact from mining related activities is noticeable at these wells, the limestone at the bottom of ZL-133 and the unknown completion details of TP-4 and the fact that ZL-133 is exposed to limestone make the water quality data questionable.

The surface water at the head of Rock Creek shows a record of declining erratic but moderate changes in SC, TDS and sulfate concentration since 1983, although the pH of the water has remained neutral (Table 3.2-26). Monitoring well TP-1 reached maximums of 1,390 μmhos/cm SC, 1,210 mg/l TDS and 657 mg/l sulfate in the sample collected in the fall of 1995, although the pH has remained near neutral since installation of the well in 1983.

Domestic water for the town of Landusky is currently attained from the TP series of wells, a contingency well constructed in the shales exists to the south of Landusky, although yields are limited and it is not presently on line (personal communication C. Russell, June 1995). Bottled drinking water is currently available to Landusky residents by ZMI.

<u>Mill Gulch</u>. Groundwater quality data for Mill Gulch was reviewed from the following wells: ZL-126 (alluvium) and ZL-121, ZL-122, ZL-128, ZL-129, and ZL-130 (fractured metamorphics, upper Mill Gulch now covered by the waste rock dump); ZL-155, ZL-156 (replacement alluvial wells at base of waste rock dump); ZL-157 (replacement bedrock well, completed in syenite porphyry volcanics); ZL-105 (limestone well, downgradient of 84 leach pad); ZL-108, ZL-118 and ZL-112A, ZL-158, ZL-159, and ZL-160 (limestone next to the process area), ZL-109 (limestone downgradient of the process area) and ZL-136 (sandstone) and, ZL-137 and ZL-138 (alluvial wells above the confluence of Mill Gulch and Rock Creek).

Table 3.2-27 summarizes alluvial and bedrock groundwater quality data in the Mill Gulch drainage. Monitoring well ZL-126, completed in alluvium near the head of Mill Gulch, has monitoring data for 1987 and 1988 only; however, the effects on groundwater quality at this time are clear. During these two years, pH values dropped from 6.2 to 3.7, SC increased from 232 to 745 μmhos/cm, and TDS increased from 179 to 458 mg/l. No cyanide was detected within this two-year period. A few hundred feet downstream ZL-122 completed in bedrock at 45 feet was also affected by mining activities. During the period 1986 to 1991, the pH dropped from 7.0 to 6.6 and SC, TDS and sulfate concentrations all increased but to a lesser degree than ZL-126. Monitoring well ZL-121 is positioned next to ZL-122, but reaches a total depth of 100 feet. The static water level in the well is at 11 feet below ground level, indicating that the bedrock is fully saturated and that little vertical potential exists between the alluvium and the underlying bedrock. Water quality data at ZL-121 show the water to possibly be effected by mining activities further upstream. Although the pH, SC, sulfate and TDS concentrations have remained stable. Iron concentrations have increased from 0.07 to 5.2 mg/l.

Shallow bedrock groundwater in upper Mill Gulch, below the waste rock dump, was monitored by wells ZL-128, ZL-129, and ZL-130 between 1988 and 1992. All three wells were completed in fractured metamorphics at depths varying from 22 to 66 feet. These monitoring sites have been replaced by three new wells, ZL-155, ZL-156 and ZL-157. Monitoring wells ZL-129 and ZL-130 showed improving groundwater quality trends between 1988 and 1992. However, ZL-128 shows significant effects from mining activity. Only a slight decrease in pH has occurred from 7.2 to 6.2; however, water quality indicators such as SC, TDS and sulfate have increased substantially reaching maximum concentrations of 1,260 μmhos/cm, 1,030 and 517 mg/l, respectively (Table 3.2-27). The disparity in water quality between these wells may be due to preferential flow in weathered bedrock.

Water quality data from replacement wells ZL-155 and ZL-157 completed in alluvium and bedrock respectively show no impact from ARD or process chemicals. However, ZL-156 an alluvial well, had a pH of 6.5, SC concentration of 1,350 μmhos/cm, TDS of 1,130 mg/l, and a sulfate concentration of 699 mg/l in the sample collected in the spring of 1994, indicating ARD is impacting the alluvial groundwater quality.

TABLE 3.2-26
ROCK CREEK GROUNDWATER QUALITY SUMMARY

	REPRESENTATIVE OF BASELINE				OPERATIONAL					
	Bedrock				Bedrock		Alluvium			
	Limestone Downstream ZL-133 (1989-1995)		Downstream TP-4 (1990-1995)		Syenite Porphyry Upgradient ZL-131 (1989-1995)		Upgradient ZL-132 (1990-1995)		Downgradient TP-1 (1983-1995)	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of Samples	16		9		17		17		34	
pH S.U.	7.3-8.1	7.76	7.4-7.9	7.5	6.0-7.6	6.87	3.3-6.0	4.46	6.5-8.0	7.49
SC μmhos/cm	286-587	426	669-748	700	259-1,240	534	190-3,180	1,551	354-1,390	720
TDS mg/l	190-392	273	370-435	400	188-1,080	374	140-3,550	1,451	193-1,210	523
SO_4 mg/l	57-144	92.5	64-73	70.4	65-806	210	71-2,360	995	190-657	390
CN mg/l	ND		ND		ND-0.006	0.003	ND-0.01	0.0031	ND-0.006	0.004
NO_2+NO_3 mg/l	ND-0.110	0.052	ND-0.06	0.03	ND-0.080	0.03	0.22-2.95	1.75	0.39-7.24	3.15
NH_3 mg/l	ND-0.10	0.056	ND-0.3	0.18	ND		ND-0.10	0.069	ND	
Hardness as CaCO3 mg/l	148-337	229	198-255	232	128-713	239	66-1,550	714	183-845	407
Ca mg/l	41-84	62.0	49-64	58	38-146	64.6	18-377	173	89-220	140
Mg mg/l	11-24	17.5	19-23	21	8-31	13.7	5-152	68	27-72	44.5
K mg/l	2-4	2.9	4-5	4.2	2-5	3.308	3-8	5.6	2-5	3
Na mg/l	4-7	5.1	63-84	75	10-25	13.8	8-73	33.9	9-23	13
Cl mg/l	ND-1.0	0.54	2-2	2	ND-3.0	0.85	1-10	4.27	2-11	6.4
HCO_3 mg/l	124-198	164	364-431	388	55-135	88.5	3-10	6.2	163-261	196
Al mg/l	ND		ND		ND-0.3	0.113	0.2-124.0	45.5	ND	
As mg/l	ND		ND		ND-0.038	0.019	ND		ND	
Cd mg/l	ND-0.001	0.0005	ND		ND-0.008	0.005	ND-0.08	0.046	ND	
Cu mg/l	ND		ND		ND		ND-0.30	0.101	ND	
Fe mg/l	ND-0.1	0.032	ND-0.51	0.35	0.35-13.3	3.75	ND-1.21	0.35	ND-0.1	0.38
Pb mg/l	ND-0.02	0.009	ND		ND-0.005	0.0045	ND-0.06	0.03	ND-0.01	0.006
Mn mg/l	ND-0.15	0.084	ND		0.76-8.56	3.506	1.37-46.70	24.3	ND	
Zn mg/l	ND-0.12	0.03	ND-0.05	0.02	0.13-0.92	0.455	0.25-9.21	4.497	0.01-0.05	0.026

Note: No pre-1979 (baseline data) available

NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated

TABLE 3.2-27
MILL GULCH GROUNDWATER QUALITY SUMMARY

	OPERATIONAL							
			Bedrock				Alluvium	
	Metamorphics Upgrade ZL-121 (1986-1991)		Metamorphics Upgradient ZL-128 (1988-1992)		Limestone Upgradient ZL-108 (1982-1995)		Downgradient ZL-137 (1990-1995)	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of Samples	11		13		39		14	
pH S.U.	6.5-7.4	6.9	6.2-7.5	6.95	6.8-8.0	7.53	7.4-7.8	7.64
SC μmhos/cm	342-460	398	233-1260	686	630-3,150	915	564-1,154	819
TDS mg/l	226-353	269	154-1030	530	335-2,720	594	395-889	617
SO_4 mg/l	107-137	120	83-517	303	61-116	93.8	180-458	296
CN mg/l	ND		ND		0.08-125.00	18.25	ND	
NO_2/NO_3 mg/l	ND		ND-4.3	2.3	5.6-9.7	6.21	0.61-4.20	2.02
NH_3 mg/l	ND		ND		ND-0.5	0.262	ND	
Hardness as CaCO3 mg/l	152-239	192	87-738	363	250-1,001	450	315-669	477
Ca mg/l	46-68	5.5	23-145	100	57-81	65.9	83-170	123
Mg mg/l	12-18	14	7-46	26.2	55-71	64.6	26-60	41.2
K mg/l	1-5	3	3-4	3.33	2-2	2	3-5	3.92
Na mg/l	8-14	11	6-18	14	15-35	22.3	9-20	12.8
Cl mg/l	0.5-1.0	0.73	0.5-2.0	[0.23]	1-69	12.4	2-6	4.06
HCO_3 mg/l	86-147	10.6	17-123	73.11	382-436	408	164-231	199
Al mg/l	ND		0.05-0.40	0.18	ND		ND	
As mg/l	ND		0.03-0.50	0.10	ND-0.14	0.036	ND	
Cd mg/l	ND		ND-0.002	0.001	ND		ND	
Cu mg/l	ND		ND		ND-0.24	0.068	ND	
Fe mg/l	0.07-5.22	3.0	0.15-2.31	1.2	ND		ND	
Pb mg/l	ND		ND-0.005	0.0014	ND		ND	
Mn mg/l	0.88-0.88	0.88	0.65-6.43	2.9	0.06-0.11	0.095	ND	
Zn mg/l	0.05-0.12	0.08	0.04-4.02	1.1	0.07-0.37	0.15	ND-0.040	0.033

Note: No pre-1979 (baseline data) available
NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated

Monitoring wells placed downgradient of the Landusky processing plant area to the west of Mill Gulch (ZL-108, ZL-118 and ZL-112A) are completed in limestones. Well ZL-108 has been monitored since 1982, ZL-118 since 1983, but ZL-112A was not installed until 1989. Cyanide concentrations were detected in ZL-118 in every sample up until 1987 and again during 1990 - 1991, reaching maximum levels of 0.110 mg/l (tot) and 0.011 mg/l (WAD). Well ZL-112A has detected cyanide in every sample since its installation, reaching maximum concentrations of 0.054 mg/l (tot) and 0.039 mg/l (WAD). SC and TDS have been constant and relatively low throughout, and pHs have remained near neutral. Monitoring well ZL-108 has recorded significant cyanide concentrations since 1982, with a maximum concentration of 125 mg/l reached in the fall of that year (Table 3.2-27). After 1983, concentrations dropped dramatically, although a high of 23.1 mg/l was recorded during 1988. The above periods of cyanide contamination are all attributable to specific spill and liner failure events at the process plant and ponds.

A group of monitoring wells were installed in the Landusky plant yard during 1994 in response to a pond leak. These wells, which include ZL-158 and 159, show detectable total cyanide concentration in the four samples gathered during 1994 and 1995, with a maximum of 0.502 mg/l cyanide recorded during August 1994. Specific conductivities have been moderately elevated in all three wells, with ZL-159 reaching the maximum of 1,580 mg/l during August of 1994. The pH of the groundwater has remained near neutral in samples from all three wells.

Monitoring well ZL-109 is completed in limestone within the drainage containing the process plant area and the 80/82 pad complex. The well, located approximately 1,400 feet downgradient of the plant area detected total cyanide in 1982 and 1983, but concentrations have been below detection limits since.

The pH of the groundwater at this location has remained neutral since sampling began in 1982. However, TDS and sulfate concentrations have been moderately high, averaging 1,118 mg/l and 527 mg/l, respectively. Metals within these samples are generally below detection limits. The moderately high TDS but neutral pH may represent neutralized ARD within the limestone.

At the bottom of Mill Gulch, above the confluence with Rock Creek, a pod of wells was installed in 1990 to monitor the water quality in the sandstone bedrock and the overlying alluvium. Water levels measured in the sandstone well (ZL-136) are above the alluvium/ sandstone contact and at a similar level to those measured in the alluvium. This indicates that the sandstone has a vertical upward hydraulic gradient in this area or that the sandstone well has a poor completion and is hydraulically connected to the overlying alluvium. All three wells have shown constant, neutral pH values and no detections of cyanide. Monitoring well ZL-138, constructed in alluvium has undergone a gradual increase in sulfate and TDS reaching maximums of 515 mg/l and 908 mg/l, respectively, in the spring of 1995. Monitoring well ZL-136 constructed in the sandstone bedrock had reached maximums of 366 mg/l sulfate, 763 mg/l TDS, and 1,010 μmhos/cm SC in the spring sampling round of 1995. These increases suggest that neutralized ARD-affected water is currently reaching the bottom of Mill Gulch within the alluvium with the sulfate concentration remaining elevated after the pH has been neutralized and metals precipitated. This neutralizing potential may come from limestone outcrop in the stream bed, calcareous material in the sandstone itself, or limestone alluvium.

Montana Gulch. Groundwater quality data for Montana Gulch was reviewed from: monitoring wells ZL-119 (completed in porphyry volcanic bedrock, immediately downgradient of the 83 and 85/86 leach pad), ZL-123, ZL-124, ZL-125 (a pod of alluvial wells, downstream of the 85/86 pad contingency pond), ZL-115 and ZL-116 (limestone bedrock wells, within eastern tributaries to Montana Gulch pad) and ZL-112A, ZL-113 and ZL-114 (limestone bedrock wells, located in the minor tributaries draining the southern portion of the 83 pad).

Table 3.2-28 summarizes alluvial and bedrock groundwater data within the Montana Gulch drainage. Groundwater samples have been gathered at ZL-119 since 1985, and cyanide has been detected in every sample collected between 1992 and 1995, having a maximum concentration of 0.125 mg/l (tot) cyanide during the fall 1992 sampling event. Water quality indicators such as sulfate, SC and TDS have been erratic at this location, with maximum values of 190 mg/l, 940 μmhos/cm and 577 mg/l, respectively, indicating only minor ARD impacts. The cyanide contamination at this location is associated with a pipeline rupture below the 83 pad in 1992.

The pod of alluvial monitoring wells (ZL-123, ZL-124 and ZL-125) were installed in 1986 in response to the failure of the 86 leach pad liner (Hydrometrics, 1986). Cyanide was detected during 1986 and 1987 at ZL-123 and ZL-124 but not until 1987 at ZL-125. The maximum cyanide concentration at ZL-123 monitored in relation to the liner failure in 1986 was 0.032 mg/l total cyanide. Cyanide was detected in the alluvium again after 1992 as a result of a process fluid pipe break associated with the 83 leach pad.

TABLE 3.2-28
MONTANA GULCH GROUNDWATER QUALITY SUMMARY

	OPERATIONAL					
	Bedrock		Alluvium			
	Porphyry Igneous Upstream ZL-119 (1985-1995)		Downstream ZL-113 (1983-1995)		ZL-125 (1986-1995)	
	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
No. of Samples	31		35		30	
pH S.U.	7-8	7.51	6.5-7.9	7.17	7.0-9.5	7.43
SC μmhos/cm	488-940	678	541-2,450	1,672	602-1,250	964
TDS mg/l	293-577	412	497-0.036	1,448	390-986	702
SO_4 mg/l	91-190	125	27-1,180	845	131-562	337
CN mg/l	ND-0.125	0.027	ND-0.04	0.013	ND-0.02	0.0048
NO_2/NO_3 mg/l	3.35-5.67	2.55	0.27-6.23	4.52	0.87-2.90	1.75
NH_3 mg/l	ND		ND		ND	
Hardness as CaCO3 mg/l	73-435	314	308-1,760	1,137	290-703	529
Ca mg/l	20-91	68.5	51-303	229	77-191	137
Mg mg/l	6-41	32.8	44-234	177	24-55	40.3
K mg/l	1-3	2.28	2-3	2.57	2-4	2.72
Na mg/l	2-178	39.6	2-8	6.33	15-27	18.2
Cl mg/l	1-18	6.12	3-4	3.33	1-6	2.22
HCO_3 mg/l	271-356	309	339-589	523	163-353	226
Al mg/l	ND		ND		ND	
As mg/l	ND		ND		ND	
Cd mg/l	ND		ND-0.002	0.001	ND	
Cu mg/l	ND		ND		ND-0.02	0.006
Fe mg/l	ND		ND-0.11	0.055	ND-0.140	0.061
Pb mg/l	ND		ND-0.03	0.013	ND-0.01	0.007
Mn mg/l	ND		ND-0.02	0.015	ND-0.03	0.014
Zn mg/l	0.01-0.07	0.025	ND-0.39	0.124	ND-0.05	0.022

Note: No pre-1979 (baseline data) available
NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated

The increase in SC, TDS and sulfate concentrations observed at ZL-123 is typical of the three wells, reaching maximum concentrations of 1,220 μmhos/cm, 981 mg/l and 603 mg/l respectively in the fall of 1993. This pattern illustrates some moderate levels of ARD impact derived from the Montana Gulch waste rock dump, the 85/86 leach pad buttress and/or underdrain, and/or the August Adit.

The monitoring record from ZL-115 and ZL-116 constructed in limestone within eastern tributaries to Montana Gulch is characterized by neutral pHs, moderate SC, TDS and sulfate concentrations. These two monitoring wells could potentially be representative of baseline conditions in limestone within the Little Rocky Mountains.

Monitoring wells ZL-113 and ZL-114R are also constructed in limestone but are positioned in tributaries draining the 83 leach pad. The monitoring records show almost continuous detections of total cyanide since 1983 at each location, with a maximum of 0.2 mg/l at ZL-114R during 1990. Indicators of ARD such as TDS and sulfate have also been high at ZL-113 and ZL-114R. Since installation, ZL-113 has had average TDS and sulfate concentrations of 1,448 mg/l and 845 mg/l, respectively (Table 3.2-27); ZL-114 has average sulfate concentrations of 4,298 mg/l TDS and 2,658 mg/l sulfate. Of note is the neutral pH maintained at both these wells due to the buffering capacity of the limestone.

During the late seventies, an alluvial well was drilled in the Montana Gulch campground area, approximately 50 feet south of the creek (see Exhibit 2, EIS map pocket). However, because of elevated arsenic concentrations the well was never completed as a public water source. The well was capped soon after drilling and was finally plugged and abandoned in 1991 (written communication, J. Frazier, BLM Jan. 1995).

<u>King Creek</u>. Groundwater monitoring data in King Creek have been limited to two wells ZL-139 and ZL-140. The wells are constructed side by side approximately 1/4 of a mile downstream of the August Pit. Monitoring well ZL-139 was installed in 1990 to a total depth of 39 feet below ground level and screened granitic bedrock between 29 and 39 feet below ground level. In 1993 the upper 12 feet of tailing was removed from around the well so it now reaches a depth of 27 feet below ground level. Monitoring well ZL-140 was completed at approximately 12 feet below ground level in alluvium, but later excavated and removed in 1993 during the removal of historic tailing within which the well was constructed.

Groundwater quality monitoring at King Creek has been undertaken since 1990 and is summarized on Table 3.2-29. No cyanide has been detected in the groundwater from either well during this time and pH values have remained relatively constant and near neutral. During 1992, maximum SC, TDS and sulfate concentrations of 1,450 μmhos/cm, 1,240 mg/l, and 640 mg/l, respectively, were reached at the bedrock well ZL-139 (Table 3.2-29). Total nitrate concentrations at ZL-139 have been consistently elevated since its installation in 1990. Available samples from ZL-140 indicate that the alluvial groundwater in the headwaters of King Creek also has elevated nitrate concentrations. These concentrations are likely derived from fertilizers used in rehabilitation in the headwaters of the drainage, or from ANFO used as a blasting agent. In either case, the elevated nitrates indicate that the water quality at monitoring well ZL-140 has been impacted by mining-related activities. Few data are available for ZL-140 as it was often dry. However, data gathered during 1992 show the alluvial water to have been neutral in pH and to have had low levels of TDS and sulfate, averaging 505 mg/l and 223 mg/l, respectively (Table 3.2-29).

Water quality data from bedrock well ZL-139 has had moderately high TDS, SC and sulfate levels but neutral pH since monitoring began in 1990. Despite the neutral pHs at this well, the presence of elevated nitrate concentrations suggest that ZL-139 is impacted by mining activity through fractured bedrock flow or a poor well completion. Given that ZL-140 has been removed and the fact that it was often dry in the past indicates that at least two additional groundwater monitoring wells are needed at King Creek. No groundwater data are currently available from South Bighorn Creek.

<u>Summary of Landusky Area Groundwater Monitoring Results</u>

In summary, the recent and historical groundwater quality data reviewed for the Landusky mining area indicate the following:

<u>Rock Creek/Sullivan Creek</u>

- Alluvial and syenite bedrock groundwater in upper Sullivan Creek appear to be affected by ARD conditions originating from the 91 (Sullivan Park) leach pad dike and/or underlying acid generating bedrock.

- Alluvial groundwater within and below the town of Landusky has had erratic changes in SC, TDS and

TABLE 3.2-29
KING CREEK GROUNDWATER QUALITY SUMMARY

	OPERATIONAL			
	Bedrock Upper Reaches ZL-139 (1990-1995)		Alluvium Upper Reaches ZL-140 (1990-1992)	
	Range	$\bar{x}$	Range	$\bar{x}$
No. of Samples	17		10	
pH S.U.	6.5-7.7	7.19	7.1-7.7	7.3
SC μmhos/cm	783-1450	1,080	567-799	658
TDS mg/l	574-1,240	859	438-592	505
SO_4 mg/l	292-640	462	190-283	223
CN mg/l	ND		ND	
NO_2/NO_3 mg/l	4.4-19.3	10.5	2.83-3.26	3.04
NH_3 mg/l	ND		ND-0.20	0.10
Hardness as CaCO3 mg/l	446-923	631	325-437	366
Ca mg/l	139-294	198	108-141	120
Mg mg/l	22-48	34	14-20	16.3
K mg/l	2.0-5.0	3.23	3-3	3
Na mg/l	9-14	11.9	8-11	9.3
Cl mg/l	2-11	3.65	1-2	1.6
HCO_3 mg/l	132-184	166	148-181	163
Al mg/l	ND-0.1	0.053	ND-0.10	0.054
As mg/l	ND		ND	
Cd mg/l	ND-0.03	0.0009	ND-0.0005	0.009
Cu mg/l	ND		ND	
Fe mg/l	ND-0.090	0.027	ND-0.03	0.01
Pb mg/l	ND-0.030	0.007	ND	
Mn mg/l	ND-0.010	0.009	ND-0.01	0.007
Zn mg/l	ND-0.01	0.044	0.03-0.04	0.035

Note: No pre-1979 (baseline data) available

NA = Not Analyzed
ND = Not Detected
All concentrations dissolved unless otherwise stated

sulfate, suggesting it may receive flushes of affected groundwater from its drainage area. Traces of cyanide during 1983 and 1984 were detected in the two wells below the confluence with Mill Gulch.

- No cyanide has been detected in alluvial or sandstone bedrock groundwater above Rock Creek's confluence with Mill Creek.

Mill Gulch

- Construction of the 87 (Mill Gulch) heap leach pad caused an immediate impact on the alluvial and syenite bedrock groundwater directly downgradient of the pad in the form of reduced pH and increased sulfate, TDS and SC concentrations. These ARD impacts likely derive from acid generating material underlying the 87 pad.

- The Landusky process plant area on the western side of the Mill Gulch drainage has impacted the underlying limestone bedrock, in the form of cyanide contamination.

- Groundwater samples from the alluvium and the sandstone bedrock at the bottom of Mill Gulch have illustrated the effect of neutralized ARD conditions over the last three years.

Montana Gulch

- Montana Gulch alluvial groundwater downgradient of the 85/86 leach pad has been degraded by ARD and cyanide contamination. These impacts are likely derived from the upgradient Montana Gulch waste dump, a breach in the 86 pad liner, discharges from the Gold Bug and August Adits, and a leak in a process fluid line in 1992.

- Elevated arsenic concentrations from an alluvial well at the Montana Gulch campground indicate that alluvial groundwater has been affected by pre-ZMI mining activity at least as far downstream as the campground since the 1970's.

- Monitoring wells (ZL-113 and ZL-114R) downgradient of the 83 leach pad, show the limestone bedrock to have impacted by cyanide releases and ARD probably from the pad buttress. The pH within these wells is neutral and metal concentrations are low due to the neutralizing capacity of the limestone.

- Monitoring wells ZL-115 and ZL-116 may be representative of baseline groundwater chemistry for limestones in Montana Gulch.

King Creek

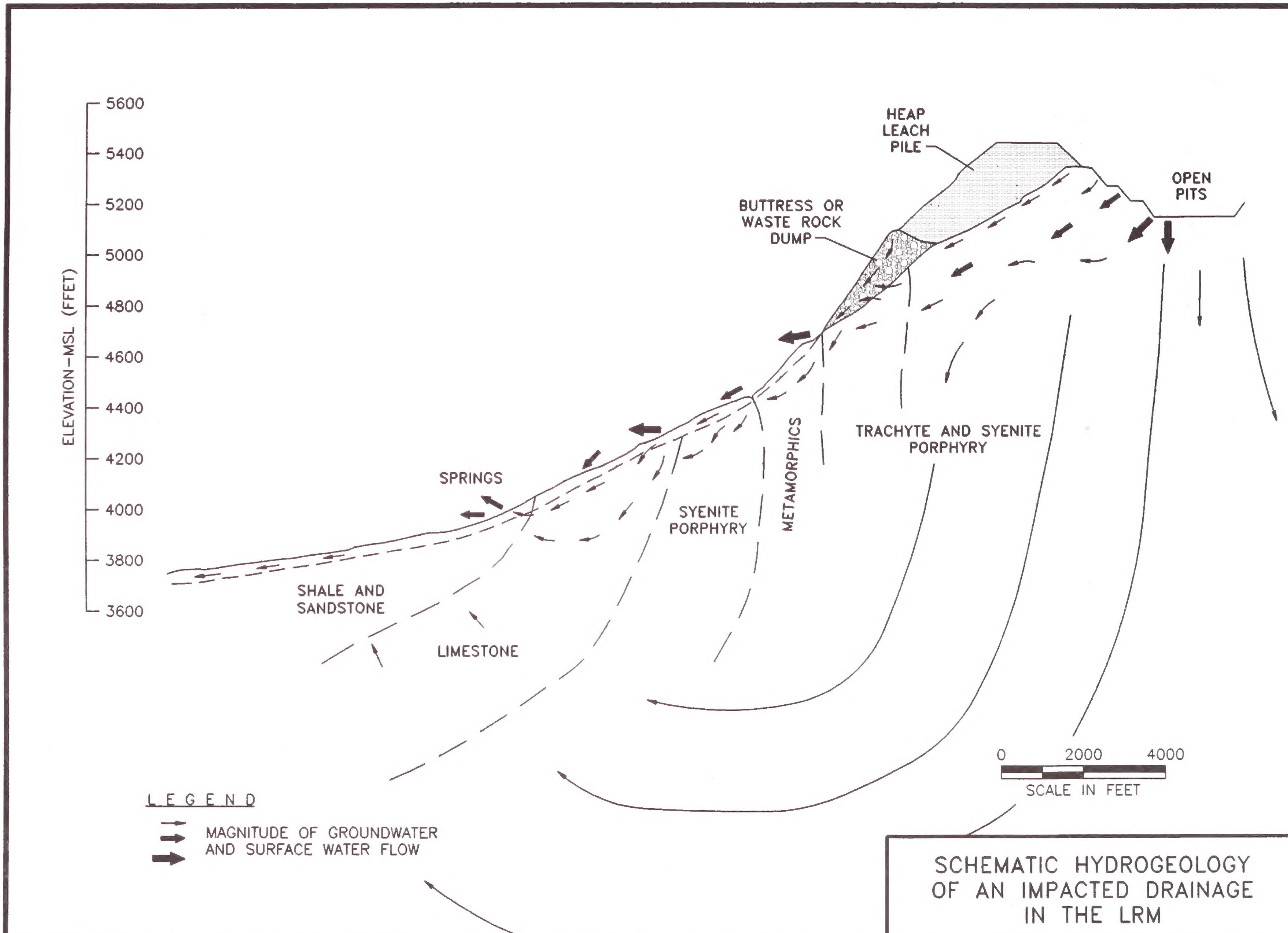
- Syenite bedrock groundwater monitored from ZL-139 has elevated TDS, SC, sulfate and nitrate levels, but a consistently neutral pH. Despite the neutral pH, the presence of elevated nitrates within this well indicates it is presently impacted by mining related activities.

- Available groundwater quality data from ZL-140 illustrates that the alluvial groundwater in King Creek has been impacted by current mining related activities resulting in slightly elevated nitrate concentrations.

3.2.6 Groundwater/Surface Water Interaction

The intermittent nature of flow within drainages and the high level of similarity between surface water and alluvial groundwater chemistry (Section 3.2.5), illustrates the high degree of surface water/alluvial groundwater interaction along most drainages within the Little Rocky Mountains. Figure 3.2-27 schematically illustrates the surface water/groundwater flow patterns throughout the length of a typical drainage within the Little Rocky Mountains and the regional relationship once outside the confines of the mountains.

In the upper parts of the Little Rocky Mountains, groundwater infiltrates directly into the unsaturated syenite porphyry rocks. Construction of the open pits, heap leach and waste rock piles has increased the land surface area available for direct infiltration and proportionally reduced the amount of direct runoff to surface water drainages. The enhanced infiltration increases the volume of water available to interact with the rock (bedrock and waste rock, spent ore etc.) and thus increases the potential for generation of ARD. A percentage of the groundwater infiltrating into the pits flows towards, and then discharges to the streams and valley alluvium through springs and seeps located in the upper reaches of the drainages (Figure 3.2-27). Groundwater flow from the pits towards the valleys is possibly facilitated by enhanced permeability along faulted and brecciated zones. Another portion of the recharge infiltrates vertically into the syenite porphyry bedrock. This near vertical flow path will eventually contribute to the recharge of the Madison Group limestones or its overlying sedimentary formations.



SCHEMATIC HYDROGEOLOGY
OF AN IMPACTED DRAINAGE
IN THE LRM

FIG. 3.2-27

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However, the long distance and resulting long duration of time (possibly thousands of years) will result in the recharge chemistry equilibrating with the regional groundwater.

Surface water flow in the drainages is intermingled with alluvial groundwater flow. Available recharge to the drainages flows in and out of the alluvium depending on the gradient of the stream and permeability of the alluvial sediments.

Some recharge to the Madison Group limestones appears to occur in the Little Rocky Mountains by infiltration of precipitation from streams where the limestones are close to, or at the surface. Recharge to the limestones is likely enhanced by their near vertical dip angle around the periphery of Little Rocky Mountains and the numerous solution cavities and karst features found within the upper levels of the Mission Canyon Limestone. Recharge is also facilitated by the downward vertical potential within the limestone at these locations. Streamflow is reported to decrease or disappear as water moves from the interior of the mountains across the limestone (Feltis 1983).

Karstic limestones have both primary porosity (intergranular voids) and secondary porosity such as caves, cavities and joints. These secondary features developed along pre-existing joints, bedding planes or other openings.

ARD contaminated water that enters the limestone bedrock will undergo two geochemical processes. Firstly, the acidic water will be diluted by the high alkalinity formation water. Secondly, the pH of the contaminated water will rise due to the high level of bicarbonate in the limestone water. As the pH rises, precipitation reactions will occur, dropping the iron oxyhydroxides out of the solution. Other metals will also precipitate out due to sorption onto the Fe oxyhydroxides.

Any downgradient monitoring of these neutralized waters will be characterized by increased sulfate and chloride concentrations and metals that are able to remain in solution at higher pHs such as arsenic and zinc. If cyanide contaminated waters enter the limestone, downstream groundwater samples may detect an increase in nitrate (a breakdown product of the cyanide).

At least ten springs have been identified around the flanks of the Little Rocky Mountains. Six or seven of these springs discharge from either the Mission Canyon or Lodgepole limestone units. The remainder discharge from syenite porphyry or the Cretaceous Thermopolis shale. Many of the springs are located in valley bottoms. Although they are not obviously related to any geological structures, they may be located at contacts between different geological units.

Available flow and groundwater quality data from these springs shows the discharge to be directly related to recharge in the Little Rocky Mountains. At the Big Warm Spring discharge volumes are recorded to have increased from approximately 6 ft^3/s to 9 ft^3/s, following a heavy snowstorm of May 20-21, 1974 (Feltis 1983). A change in chemical quality of the water was also observed at the Big Warm Spring. Comparison of the dissolved constituents shows a decrease in concentration during June caused by the recharge of water from the May 1974 storm. Subsequently water quantity and quality returned to baseline conditions.

Observations from monitoring wells installed by the USGS and potentiometric heads measured in existing exploratory oil wells shows an upward vertical potential within the limestones and a potentiometric surface close to or above the ground surface.

ARD impacted groundwater sampled from the limestone units in the immediate vicinity of the mining facilities is generally neutral in pH, but still contains elevated TDS and sulfate levels. No indications of ARD or mining process chemicals have been observed in any springs sampled around the periphery of the Little Rocky Mountains. A recent sampling by the USGS in cooperation with the Bureau of Indian Affairs and EPA collected samples from 9 surface water stations, 3 springs and 2 groundwater wells on the Fort Belknap Indian Reservation (USGS 1995). Analytical results show the springs and groundwater to be of a general calcium bicarbonate type with no indications of ARD. The continued good quality of the spring discharges is either due to impacted waters having not yet reached the springs, the high neutralizing capacity and dilution within the upgradient limestones or the lack of any contamination of the limestone groundwaters on the northern side of the Little Rocky Mountains.

The amount of infiltration into the regional Madison aquifer is unknown; however, the vertical upward hydraulic gradients and the many springs discharging from the limestone around the periphery of the mountains suggests that much of the recharge to the limestones within the mountains reports to the surface water system at the base of the mountains.

The key points regarding groundwater/surface water interaction in the Little Rocky Mountains are as follows:

- By excavating the open pits and constructing leach pads and waste rock piles, the mining process has significantly increased the area available for infiltration and will have proportionally decreased the volume of direct surface water runoff.

- The increased surface area for infiltration has also increased the amount of groundwater flow and potential for acid generation.

- A portion of the water that infiltrates in the upper Little Rocky Mountains discharges to surface water streams from springs, seeps, and adits throughout the length of drainages of the Little Rocky Mountains. This suggests that water contaminated by ARD may be transmitted from the groundwater system to surface water at some lower elevation. Other recharge waters infiltrate vertically following a long, slow recharge route to the sedimentary formation surrounding the Little Rocky Mountains.

- At the Zortman Mine, it appears as though groundwater from beneath the mine pits is preferentially flowing/discharging as surface water in the Ruby Gulch drainage as opposed to the Lodgepole or Alder drainages. This conclusion is supported by the high volume of low quality water in Ruby Gulch versus the good quality of surface water and groundwater in the Glory Hole/Lodgepole drainage.

- At the Landusky mine, available water level data indicates that northeast oriented shear zones are the principal features controlling groundwater flow in the vicinity of the August pit. Also, the near constant flow of water from the associated Gold Bug and August drain adits suggests that they are preferentially draining groundwater in the vicinity of the Gold Bug and August pits to the south in Montana Gulch. Some groundwater discharge from the north may also occur associated with the Suprise shear zone draining towards Swift Gulch and some perched groundwater in the Narrows fault zone potentially draining towards King Creek.

- A major regional aquifer (Madison Limestone) is found near land surface or exposed in several drainages around the flanks of the Little Rocky Mountains. Its near surface exposure and high permeability result in the potential for impacted surface or alluvial waters to directly recharge the limestone units.

- The springs surrounding the Little Rocky Mountains and artesian pressures observed within the limestone regionally, suggests that much of the direct recharge to the limestone will be returned to the surface downgradient through springs and seeps. Due to the hydrogeologic conditions mentioned above and the significant attenuation capacity of the limestone, it is unlikely that the Madison Limestone groundwaters would become contaminated beyond the margins of the Little Rocky Mountains. The water quality of the peripheral springs is currently unimpacted by mining related processes.

3.2.7 Beneficial Uses

3.2.7.1 Surface Water Use

As discussed above, numerous springs are found around the entire base of the Little Rocky Mountains. Springs and adits supply relatively constant flow to sustain a base flow in a number of drainages. These flows are used by a variety of wildlife and limited macroinvertibrate populations. Fisheries are reported to be restricted to downstream of the Montana Gulch, Rocky Creek confluence and downstream reaches of Little Peoples Creek, Lodgepole Creek and Beaver Creek.

In the Zortman and Landusky areas, there are numerous surface water rights on record for industrial and agricultural areas. Zortman Mining, Inc. owns a total of seven industrial appropriations in Ruby Gulch and Alder Gulch. Square Butte Grazing Association holds 14 appropriations of surface water within the Zortman study area as well as others below the study area. These rights are for agricultural use and typically are appropriated for the entire channel flow of the ephemeral drainages in the area. Square Butte Grazing owns rights in Goslin Flats, Camp Creek, and Ruby Creek within the study area. Also, the Winters Doctrine (1908), states that the tribe has reserved water rights that are superior to any rights under Montana or any state law (see Section 1.5.3). Surface water rights within the Zortman and Landusky mine extension areas are summarized in Table 3-2.30. The Little Peoples Creek Basin which receives water from King Creek is used as a recreational area by residents of the Fort Belknap Indian Reservation.

Little useful information is available on any impact mining operations may have had on surface water flows of the Little Rocky Mountains. Flow gauging data in the majority of the drainages has in the past been irregular and often estimated. However, permanent monitoring stations have been established in selected drainages on the northern side of the Little Rocky

TABLE 3.2-30
DEPARTMENT OF NATURAL RESOURCES & CONSERVATION (DNRC)
SURFACE WATER RIGHT LISTING BY LAND DESCRIPTION

Water Right	Use	Rate		Volume	QTR SCTN	SC	TWP	RGE	CN	UT	Source Name	Owner Name
G40EJ W184806-00	DM			.80	NESENW	17	25N	25E	PH		RUBY GULCH	FEDERAL LAND BANK OF SPOKANE
G40EJ W113794-00	DM	15.00	G	1.50	NENWSW	17	25N	25E	PH			KALAL DICK KALAL LUCILLE M
G40EJ W113795-00	CM	60.00	G	48.00	NENWSW	17	25N	25E	PH			KALAL LUCILLE M KALAL DICK
S40EJ T033479-00	MN				SENWSW	17	25N	25E	PH		ALDER GULCH	TENNARD RESOURCES INC
S40EJ W167789-00	MN	200.00	G	322.00	SENWSW	17	25N	25E	PH		ALDER GULCH	GOLD RESERVE INC
S40EJ W206598-00	MN	100.00	G	2.00	SENWSW	17	25N	25E	PH		ALDER GULCH	KALAL PERRY E
S40EJ W167785-00	MN	4.00	C	2,890.00	SWNWSW	17	25N	25E	PH		ALDER GULCH	GOLD RESERVE INC
S40EJ W167786-00	MN	1.00	C	723.00	SWNWSW	17	25N	25E	PH		ALDER GULCH	GOLD RESERVE INC
S40EJ W167787-00	MN	1.50	C	1,884.00	SWNWSW	17	25N	25E	PH		ALDER GULCH	GOLD RESERVE INC
S40EJ W167788-00	MN	3.75	C	1,351.35	SWNWSW	17	25N	25E	PH		ALDER GULCH	GOLD RESERVE INC
S40EJ W167790-00	MN	2.50	C	1,807.00	SWNWSW	17	25N	25E	PH		ALDER GULCH	GOLD RESERVE INC
S40EJ W166078-00	DM	3.00	G	1.50	NWSWSW	17	25N	25E	PH			CUMMINGS NEWTON E HOLZEY RAY
G40EJ W166077-00	MN	3.00	C			18	25N	25E	PH		ALDER CREEK	HOLMAN DONOVAN W SUNDIN ARVID N
G40EJ W037512-00	ST	5.00	G	1.60	SESESW	20	25N	25E	PH		GOSLIN	SQUARE BUTTE GRAZING ASSN
S40EJ W037487-00	ST	16.00	G	2.52	N2NW	25	25N	25E	PH&		CAMP CREEK	SQUARE BUTTE GRAZING ASSN
G40EJ W152917-00	ST	3.00	G	1.70	SESESE	25	25N	25E	PH			LAZY J D CATTLE CO
S40EJ W037501-00	ST	5.00	C	3.36	NWSWSW	26	25N	25E	PH&		CAMP CREEK	SQUARE BUTTE GRAZING ASSN
G40EJ W065372-00	WI	3.95	G	36.64	SENE	29	25N	25E	PH			USA (DEPT OF INTERIOR BUREAU OF

TABLE 3.2-30

DNRC SURFACE WATER RIGHT LISTING

(Continued)

Water Right	Use	Rate		Volume	QTR SCTN	SC	TWP	RGE	CN	UT	Source Name	Owner Name
G40EJ W065373-00	ST	3.95	G	.34	SENE	29	25N	25E	PH			USA (DEPT OF INTERIOR BUREAU OF
S40EJ T061826-00	MN				NENWNW	30	25N	25E	PH		GROUSE GULCH	CUMMINGS THOMAS HASLER FLOYD
G40EJ W065374-00	WI	2.96	G	2.84	SESE	30	25N	25E	PH			USA (DEPT OF INTERIOR BUREAU OF
G40EJ W065375-00	ST	2.96	G	.35	SESE	30	25N	25E	PH			USA (DEPT OF INTERIOR BUREAU OF
G40EJ W037506-00	ST	1.50	G	1.30	NENENE	33	25N	25E	PH			SQUARE BUTTE GRAZING ASSN
S40EJ W037502-00	ST	450.00	G	19.20	NESWNE	33	25N	25E	PH&		ALDER CREEK	SQUARE BUTTE GRAZING ASSN
G40EJ W037508-00	ST	15.00	G	2.50	SWSWNW	33	25N	25E	PH		ALDER CREEK 2	SQUARE BUTTE GRAZING ASSN
S40EJ W037486-00	ST	30.00	G	4.20		35	25N	25E	PH&		CAMP CREEK	SQUARE BUTTE GRAZING ASSN
S40M W112488-00	ST	.52	C	15.21	SENWNW	1	25N	26E	PH	X	MISSOURI RIVER	MONTANA STATE LAND BOARD
S40M W112487-00	ST	.61	C	40.05	SESWSE	2	25N	26E	PH	X	MISSOURI RIVER	MONTANA STATE LAND BOARD
G40M W169688-00	ST	1.50	G		NENESW	2	25N	26E	PH	X	COBURN CREEK	MATADOR RANCH INC
S40M W040428-00	ST	14.08	C	16.00	NESWSE	7	25N	26E	PH	X	GHAST COULEE	CRASCO ORVILLE W
S40M W040429-00	IR	100.00	C	150.00	E2	8	25N	26E	PH		BEAVER CREEK	CRASCO ORVILLE W
S40M W40430-00	IR	100.00	C	150.00	SW	8	25N	26E	PH		BAKER CREEK	CRASCO ORVILLE W
S40EJ W152937-00	ST	4.00	C	26.00	N2NWSW	28	25N	23E	PH	X	BULL CREEK	MONTANA CATHOLIC MISSION S J
S40EJ W152932-00	ST	8.00	G	10.00	S2NWSW	28	25N	23E	PH	X	BULL CREEK	MONTANA CATHOLIC MISSION S J
S40EJ P004845-00	ST			5.00	SENWNE	29	25N	23E	PH	X	CABIN CREEK	MONTGOMERY C JOHN
S40EJ W184796-00	ST	20.00	G	10.92	E2NESE	29	25N	23E	PH	X	BULL CREEK	MONTANA CATHOLIC MISSION S J
S40EJ W152944-00	ST	10.00	C	20.00	E2SESE	29	25N	23E	PH	X	BULL CREEK	WILLIAMS RAYMOND S
S40EJ P004847-00	ST			4.00	NWNWNW	30	25N	23E	PH	X	CABIN CREEK	MONTGOMERY C JOHN
S40EJ W184797-00	ST			12.00	E2NESE	30	25N	23E	PH	X	BULL CREEK	MONTANA CATHOLIC MISSION S J

TABLE 3.2-30
DNRC SURFACE WATER RIGHT LISTING
(Concluded)

Water Right	Use	Rate		Volume	QTR SCTN	SC	TWP	RGE	CN	UT	Source Name	Owner Name
S40EJ W152928-00	ST			8.60	NESWNW	33	25N	23E	PH	X	CABIN CREEK	MITCHELL WINSTON N
S40EJ W152929-00	ST			33.50	NWNENW	34	25N	23E	PH	X	CABIN COULEE	MITCHELL WINSTON N
S40I W017296-00	MN	1,122.00	G	95.50	NENE	14	25N	24E	PH		LITTLE PEOPLES CREEK	LAFOND LLOYD J LAFOND MILDRED S
G40EJ W152945-00	ST	25.00	G	10.82	NESWSW	20	25N	24E	PH			MONTANA CATHOLIC MISSION S J
G40EJ P023219-00	MN	250.00	G	100.00	SENENW	22	25N	24E	PH			LANDUSKY MINING INC
G40EJ W019674-00	DM	5.00	G	1.50	SENESE	22	25N	24E	PH			ZORTMAN MINING CO
G40EJ C037323-00	DM	5.00	G	1.50	SWNESE	22	25N	24E	PH			EREAUX ROY G EREAUX MARIAN S
G40EJ W184801-00	DM	15.00	G	3.25	NWNWSW	27	25N	24E	PH	X	ROCK CREEK	HEPPNER HAROLD H
G40EJ W184800-00	DM	15.00	G	3.25	NESWSW	27	25N	24E	PH	X	ROCK CREEK	HEPPNER HAROLD H
G40EJ W184802-00	DM	7.50	G	1.62	SWSWSW	27	25N	24E	PH	X	ROCK CREEK	HEPPNER HAROLD H
G40EJ W184799-00	ST	7.50	G	1.62	E2E2E2	28	25N	24E	PH		MONTANA GULCH	HEPPNER HAROLD H
G40EJ W184803-00	DM	7.50	G	1.62	NWSWNE	28	25N	24E	PH			HEPPNER HAROLD H
S40EJ W152946-00	IR	200.00	C	949.60	E2NENE	30	25N	24E	PH&		BULL CREEK	WILLIAMS RAYMOND S
S40EJ W152938-00	ST	12.00	C	23.00	E2NESW	31	25N	24E	PH&	X	SLIPPERY ANN HUD CREEK	WILLIAMS RAYMOND S
S40EJ W037511-00	ST	30.00	G	2.50	NW	32	25N	24E	PH		MUD CREEK	SQUARE BUTTE GRAZING ASSN
G40EJ W018250-00	ST	3.00	G	1.00	NWSESE	36	25N	24E	PH			MONTANA STATE LAND BOARD
S40EJ W166074-00	MN	3.75	C	2,710.00	SWNWSE	7	25N	25E	PH		RUBY GULCH	GOLD RESERVE INC
G40I W166075-00	MN	6.25	C	4,517.00	NESESE	7	25N	25E	PH			GOLD RESERVE INC
S40EJ W166073-00	MN	30.00	G	48.00	NWSWSE	7	25N	25E	PH		RUBY GULCH	GOLD RESERVE INC

Mountains by the USGS, yielding continuous monitoring data as far back as 1987. Unfortunately no earlier data are available. Figure 3.2-28 shows annual total and maximum flows for Little Peoples Creek, Lodgepole Creek and Little Warm Creek. Since 1987 no long-term changes in surface flow are apparent, although an initial decrease in flow between 1978 and 1980 occurred in Little Peoples Creek near the town of Hays. Although monitoring data is not available it is expected that surface water flow and spring discharge to the north of the Landusky mining operation would have decreased when the August and Gold Bug Adits were completed in the 1960's, effectively diverting a large percentage of the catchment to the south.

3.2.7.2 Groundwater Use

Domestic water supplies in the towns of Zortman and Landusky depend entirely upon groundwater. Most of the recorded wells near the towns are constructed in alluvial deposits or shallow sandstones at depths of less than 200 feet. As a result of a series of cyanide incidents during 1982/83 and resultant impacts to Alder Gulch surface water and alluvial groundwater, the Zortman community water collection gallery (Z-8) has been replaced by one community well Z-8A, installed by ZMI. The well is completed into the Madison Group and screened from 395 to 738 feet in depth. Landusky has shallow domestic wells constructed in both bedrock and alluvium. Drinking water provided by ZMI is currently available to Landusky residents. Groundwater rights within the Zortman and Landusky mine extension areas are summarized in Table 3.2-31. Shallow alluvial deposits within drainages such as Little Peoples Creek provide domestic water supplies for numerous homes (Feltis 1983). Wells for domestic use have also been drilled into the Eagle Sandstone, sandstone beds of the Kootenai Formation and sandstone and limestone beds of the Ellis Group that dip into the plains from the mountains (Feltis 1983). During historic and recent mining operations, groundwater from wells constructed in the fractured porphyry rock has been used for milling, cyanide processing of gold ores and heap leaching.

3.2.8 Regulatory Criteria

The water-use criteria for all drainages in the Little Rocky Mountains is contained ARM 16.20.607. All surface water which drains to the Missouri River (i.e. Ruby and Rock Creek) are currently classified as C3 by the Montana Department of Health and Environmental Science. Waters classified as C-3 are suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agricultural and industrial water supply. The water quality standards for C-3 streams are located in ARM 16.20.624. The northern creeks (Beaver, Lodgepole, King Creek, and South Bighorn) are classified as B-1. Water classified as B-1 should be suitable for drinking, culinary and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply (ARM 16.20.618). The water quality standards for streams are located in ARM 16.20.618.

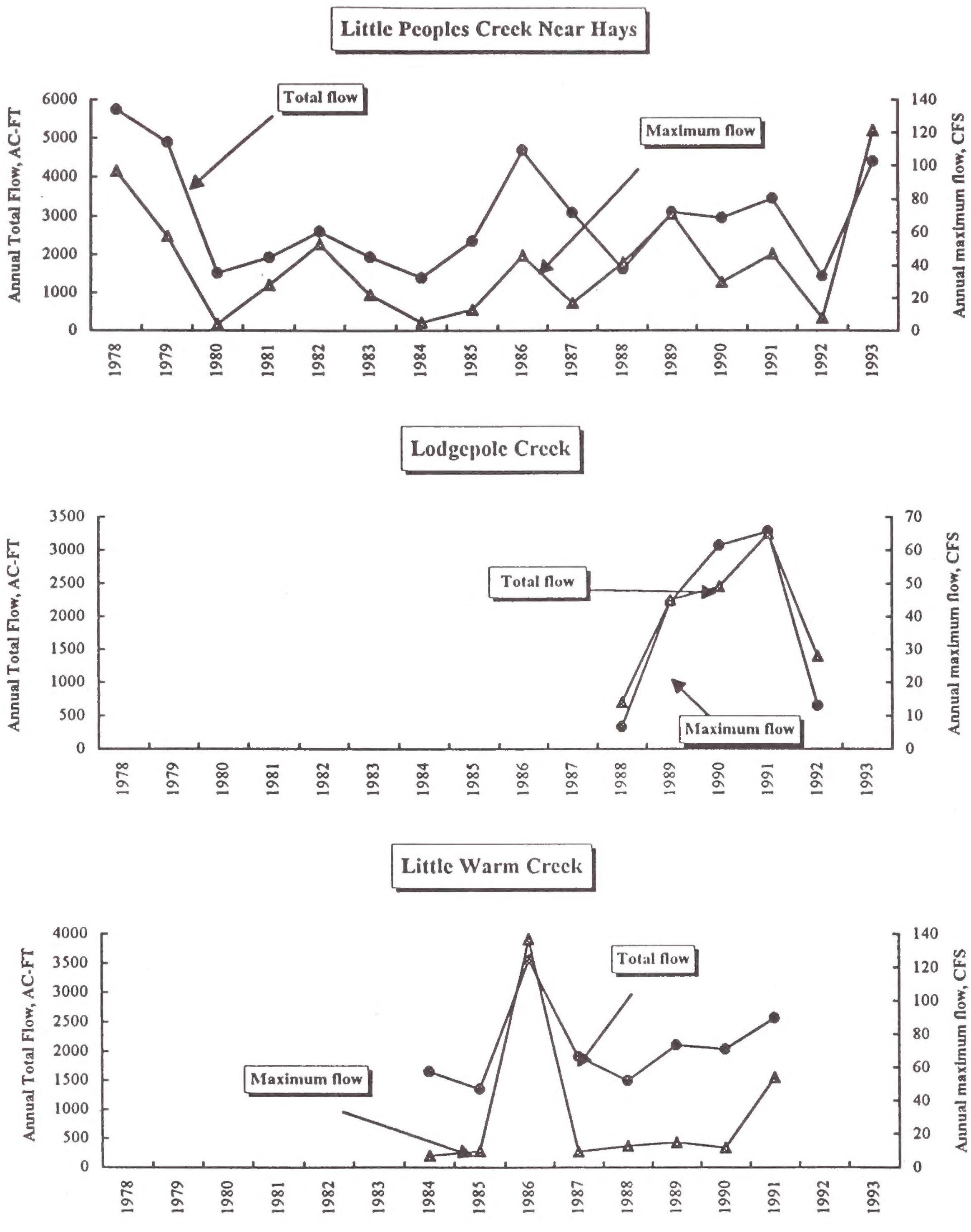
Groundwater use classification is contained in ARM 16.20.1002. Groundwater quality standards are presented in Circular WQB-7. Only standards listed in WQB-7 as "human health standards" apply to groundwaters.

Any waste discharge to state water must obtain a discharge permit and comply with the terms of that permit. Effluent limits are established in permits which are based on nondegradation, water quality standards, natural conditions and treatment standards among other factors. A discharge permit is not necessary for discharges to groundwater. However, groundwater discharges must comply with non-degradation and mixing zone rules, as well as water quality standards contained in WQB-7.

Regulatory standards such as aquatic life standards and human health criteria for surface water have been exceeded in the headwaters of many drainages in the Little Rocky Mountains. Parameters exceeding water quality criteria are generally restricted to metals, leached out of the rock by ARD. However, exceedences of 0.2 total mg/L cyanide have occurred in Ruby Gulch surface water (Z-1 and Z-10) and groundwater (ZL-101) due to leaks/spills. In the process plant area, Alder Gulch surface water (Z-8) and groundwater (AG-201) (due to

1986 LAD) and Mill Gulch groundwater (ZL-104, ZL-108, ZL-118 and ZL-158) within the process plant area.

Once reaching the perimeter of the Little Rocky Mountains, water quality degradation in the past has occurred only after specific events such as extreme precipitation. Due to efforts to construct and proposals to expand capture systems in accordance with the Improvement Plan downstream exceedences have been reduced.



SOURCE: USGS MONITORING DATA

CHANGE IN FLOW
OF NORTHERN DRAINAGES
LITTLE ROCKY MOUNTAINS

FIG. 3.2-28

TABLE 3.2-31
DEPARTMENT OF NATURAL RESOURCES & CONSERVATION (DNRC)
GROUND WATER RIGHT LISTING BY LAND DESCRIPTION

Water Right	Use	Rate		Volume	QTR SCTN	SC	TWP	RGE	CN	UT	Source Name	Owner Name
G40EJ W065370-00	WI	.72	G	.79	NENE	16	25N	25E	PH		WELL	USA (DEPT OF INTERIOR BUREAU OF
G40EJ W065371-00	ST	.72	G	.34	NENE	16	25N	25E	PH		WELL	USA (DEPT OF INTERIOR BUREAU OF
G40EJ C053271-00	MC	90.00	G	135.00	SWSESE	16	25N	25E	PH		WELL (DEPTH - 738 FT)	ZORTMAN WATER USERS ASSN
G40EJ G053271-00	MC	90.00	G	135.00	SWSESE	16	25N	25E	PH		WELL (DEPTH - 738 FT)	ZORTMAN WATER USERS ASSN
G40EJ G053271-01	MC	90.00	G	135.00	SWSESE	16	25N	25E	PH		WELL	ZORTMAN WATER USERS ASSN
G40EJ C031281-00	CN	24.00	G	38.71	SESWSE	16	25N	25E	PH		WELL (DEPTH - 738 FT)	NESBIT HENRY
G40EJ W011159-00	DM	10.00	G	25.00	SWNWSW	16	25N	25E	PH		WELL	MONTANA STATE LAND BOARD
G40EJ W006432-00	DM	3.00	G	1.50		17	25N	25E	PH		WELL	SOUTHWICK MARDA R SOUTHWICK JAY W
G4OEJ W013060-00	ST	15.00	G	1.25	NENWSW	32	25N	25E	PH		WELL	SQUARE BUTTE GRAZING ASSN
G40EJ C004613-00	ST	4.00	G		SENW	33	25N	23E	PH		WELL	MITCHELL WINSTON
G40I C016704-00	MN	55.00	G	3.50	SW	12	25N	24E	PH		WELL	WELCH PAULINE C
G40EJ W167791-00	MN	2.00	C	1,445.00	SWNWNE	22	25N	24E	PH		GOLD BUG ADIT	LANDUSKY MINING INC
G40EJ C069239-00	MN	90.00	G	120.51	NWNENW	22	25N	24E	PH		WELL	ZORTMAN MINING CO
G40EJ T055440-00	IN				NWNENW	22	25N	24E	PH		WELL	LANDUSKY MINING INC
G40EJ C005963-00	FW	.25	G		NENWSE	22	25N	24E	PH		WELL	DOUCETTE RANCH
G40EJ W043875-00	DM	30.00	G	1.20		27	25N	24E	PH		WELL	WILLIAMS WILLIAM E
G40EJ W047136-00	DM	70.00	G	5.00		27	25N	24E	PH		WELL	TURNER DAVID H
G40EJ C031157-00	DM	20.00	G	4.50	NE	27	25N	24E	PH		WELL (DEPTH - 60 FT)	HOULD BARBARA J
G40EJ C064020-00	DM	5.00	G	3.00	NENENE	27	25N	24E	PH		WELL (DEPTH - 187 FT)	LANDUSKY MINING INC
G40EJ W017297-00	DM	50.00	G	4.50	N2NWNE	27	25N	24E	PH		WELL	FRENCH WINNIE R

TABLE 3.2-31
DNRC GROUNDWATER RIGHT LISTING
(Concluded)

Water Right	Use	Rate		Volume	QTR SCTN	SC	TWP	RGE	CN	UT	Source Name	Owner Name
G40EJ T045103-00	ST				NWNWSW	31	25N	24E	PH		WELL	WILLIAMS RAYMOND S
G40EJ C075853-00	DM	15.00	G	1.50	SWNWNW	34	25N	24E	PH		WELL (DEPTH - 400 FT)	KOLCZAK FRANCIS
G40EJ C077139-00	IN	95.00	G	145.61	SWSE	7	25N	25E	PH		WELL (DEPTH - 450 FT)	PEGASUS GOLD CORP
G40EJ C041510-00	IN	30.00	G	48.00	NESWSE	7	25N	25E	PH		WELL	ZORTMAN MINING CO
G40EJ P042324-00	IN	500.00	G	530.00	NESWSE	7	25N	25E	PH		WELL	ZORTMAN MINING CO
G40EJ W037498-00	ST	8.00	G	2.10	SWSESW	21	25N	25E	PH		ALDER SPRINGS 1	SQUARE BUTTE GRAZING ASSN
G40EJ W037497-00	ST	3.00	G	2.10	SESENW	35	25N	25E	PH		LOWER CAMP SPRING	SQUARE BUTTE GRAZING ASSN
G40I W005563-00	MN			200.00		13	25N	24E	PH		CASCADE SPRINGS	TAYLOR J H

Available pre-1979 "baseline" data for the Little Rocky Mountains illustrates that aquatic life standards were also exceeded prior to Zortman mining activity although exceedances were restricted to a few specific locations, namely historical adit discharges. Baseline surface water data that exceeded current aquatic life criteria came from the following facilities. The Gold Bug adit discharge at Montana Gulch, with up to 0.310 mg/l As, up to 11 mg/l Fe and up to 0.88 mg/l Zn, exceeding the chronic aquatic life criteria for As and Fe of 0.19 mg/l and 1 mg/l respectively, and the acute aquatic life standard for Zn of 0.12 mg/l at 100 mg/l hardness. Exceedances in surface water was also recorded at the mine adit drainage in Alder Gulch, with 2.3 mg/l Fe and 0.8 mg/l Zn.

3.2.9 Summary of Findings

A summary of the present water quality status and related mining facilities, where present, is provided on Table 3.2-32.

In addition to the information summarized in Table 3.2-32, the following major conclusions are pertinent:

- Streams flowing from the Little Rocky Mountains are ephemeral in their upper most reaches and then become intermittent in their mid reaches, becoming ephemeral again as they leave the Little Rocky Mountains and enter the plains, but due to their current intermittent nature they do not typically support fisheries or significant macroinvertebrate populations.

- The shales underlying the Goslin Flats area are of low permeability and have naturally high TDS and sulfate concentrations.

- Pre-1979 (baseline) data shows limited degradation to water quality due to historical mining activity in most drainages.

- Post-1979 surface water and alluvial groundwaters have exhibited elevated chemical constituent concentrations on specific occasions, downstream as far as the towns of Zortman and Landusky.

- Madison limestone exposed at or near the surface in the Little Rocky Mountains has received ARD contaminated recharge due to upstream mining activity.

- No monitoring evidence is available to document a change in surface water flow due to mining activity. However, the excavation of the pits and diversion of surface water flow into these pits is expected to have decreased flows in the streams north of the mines to some minor degree.

- Due to the intermittent nature of surface water drainages of the Little Rocky Mountains, beneficial uses are limited in streams upper to mid reaches. Selected downstream reaches are used for livestock watering, recreation (campgrounds), wildlife drinking water, macroinvertebrate habitat, and possible fisheries and agricultural uses.

TABLE 3.2-32
EXISTING WATER QUALITY CONDITIONS - SUMMARY

Facility	Surface Water	Groundwater	
		Alluvium	Bedrock
		ZORTMAN	
Ruby Gulch			
Zortman Pits Zortman Process Plant 85-86 Pads 79-82 Pads	Numerous cyanide detections likely from spills at the Zortman process area and ARD effects illustrated by elevated SO_4, TDS, SC and low pH, e.g. Z-1	Alluvium in upper reach of the Gulch consists of mineralized tailings, containing groundwater with occasional cyanide detections elevated SO_4, TDS, SC and low pH, e.g., RG-109	Some bedrock wells completed in metamorphic rock show the effects of mining with low pH, elevated SO_4, TDS and SC, e.g., RG-99
	Effects from mining activity on surface water are recognized throughout the length of Ruby Gulch down to Station Z-32, approximately 8,000 feet downstream of the Zortman township. Alluvial groundwater also shows effects of mining activity throughout the length of Ruby Gulch, but only on occasions in the lower reaches. A dramatic improvement in the quality of the surface water has been observed since the initiation of capture and treatment at Ruby Gulch.		

TABLE 3.2-32
EXISTING WATER QUALITY CONDITIONS - SUMMARY
(Continued)

Facility	Surface Water	Groundwater	
		Alluvium	Bedrock
		ZORTMAN	
Alder Gulch			
Waste Rock Dump	Deteriorating water quality is illustrated by decreasing pH and occasional elevated SO_4, TDS, and SC, e.g. Z-13	Alluvial groundwater has been adversely impacted by the mining process illustrated by numerous cyanide detections and occasional elevated SO_4, SC and TDS, e.g., AG-202	Apparently unaffected by the rock dump
LAD Area 79-82 Pads 84 Leach Pad 83/89 Pads	Deteriorating water quality illustrated by occasional cyanide detections, elevated SO_4, TDS, SC and low pHs, e.g., Z-8		Shallow bedrock appears to be effected by the mining facilities illustrated by cyanide detections and elevated SO_4, TDS and SC, e.g., AG-202
	Effects from the waste rock dump are recognized in the surface water of Alder Creek by the decreasing pH and elevated SO_4, TDS, and SC. Surface water quality is also effected by spills and land application of process chemicals, with cyanide detections below the Alder Spur confluence. Effects to alluvial and bedrock groundwater are illustrated by cyanide and occasional elevated SO_4, SC, and TDS. An improvement in surface water quality from Carter Spur and Alder Spur has been recognized since the installation of capture systems in 1992. It is unclear how far downstream the groundwater is effected and/or if it contributes to the decreased groundwater quality seen in lower Ruby Gulch.		

TABLE 3.2-32
EXISTING WATER QUALITY CONDITIONS - SUMMARY
(Continued)

		Groundwater	
Facility	**Surface Water**	**Alluvium**	**Bedrock**
	***Details of examples cited can be found in water chemistry summary tables.ZORTMAN**		
Goslin Gulch			
No existing facilities	Naturally high levels of TDS and sulfate and a neutral pH	Similar to surface water, showing elevated TDS, sulfate and a neutral pH	Bedrock wells show increasing levels of sulfate and TDS with time.
	The neutral pHs but high sulfate, TDS, etc., are due to ongoing water/rock interaction with sediments and bedrock consisting of mineral-rich shales which are reduced and have high sulfate concentrations.		
Lodgepole Creek			
Zortman Pit Complex	Neutral pHs, low TDS and sulfate, no cyanide detections, e.g. Z-27	(Spring water) Neutral, low TDS and sulfate, good quality water, e.g. Z-6	
Beaver Creek			
No existing facilities	Neutral pHs, low TDS and sulfate e.g. Z-31	No groundwater data available.	
	The neutral pH, low TDS, sulfate, no cyanide detection and neutral concentration at or below detection limits, indicate that impacts to Lodgepole Creek have only been short-term and Beaver Creek has not been impacted by ZMI mining activity.		

TABLE 3.2-32
EXISTING WATER QUALITY CONDITIONS - SUMMARY
(Continued)

		Groundwater	
Facility	**Surface Water**	**Alluvium**	**Bedrock**
		LANDUSKY	
Rock Creek			
91 (Sullivan Park) Pad	Surface water has been effected by construction of the pad with pHs reduced to 2.7 after 1991 and increases in SO_4, TDS and SC.	Substantial effects are seen in alluvial groundwater at the base of the pad. Illustrated by reduced pH and increases in SO_4, TDS and SC. No cyanide has been detected, e.g., ZL-132	Bedrock groundwater immediately below the 91 pad appears to be effected illustrated by a subtle trend of decreasing pH and increasing SO_4, TDS and SC, e.g., ZL-113
	Water effected by the 91 leach pad buttress or underdrains appears to be captured or significantly diluted by nonimpacted water from the upper reaches of Rock Creek. Below the confluence of these creeks, effects from mining activity are only occasionally recognized down to the confluence with Mill Creek.		
Mill Gulch			
87 Pad	Moderate increases in SO_4, TDS and SC during 1987-1988. Monitoring station was covered by the 1988 Mill Gulch Waste Dump, e.g. L-18	Moderate increase in TDS, SO_4 and SC recorded during 1987-1988 period. Decreasing pH, e.g. ZL-126	Slight effect on bedrock groundwater, slightly reduced pH and minor increases in TDS, SO_4 and SC, e.g., ZL-122

TABLE 3.2-32
EXISTING WATER QUALITY CONDITIONS - SUMMARY
(Continued)

Facility	Surface Water	Groundwater	
		Alluvium	Bedrock
LANDUSKY			
Mill Gulch Waste Rock Dump	Moderate effects illustrated by elevated SC, TDS, SO_4 and low pH during 1991, e.g., L-25	Occasional effect on alluvial groundwater only. Occasional elevated SO_4, TDS, and SC, e.g., ZL-128	No effect is recognized in the bedrock groundwater, e.g., ZL-130
Landusky Process Plant Area	Effect on surface water illustrated by constant detections of cyanide, e.g., L-8	No data available	Effect of leaks/spills on limestone bedrock illustrated by near constant detections of cyanide, e.g., ZL-118
Mill Gulch	The 87 pad underdrain effected surface water, alluvial and bedrock groundwater illustrated by moderate increases in SO_4, TDS and SC. Cumulative effects from the waste rock dump and the 87 pad are restricted to surface water and the alluvium. The process plant area has spilled/leaked cyanide to surface water and bedrock groundwater on the western side of drainage. ARD effects in the surface water and alluvial groundwater have reached the Mill Gulch Rock Creek confluence.		
Montana Gulch			
Montana Gulch Waste Rock Dump Gold Bug Pit 84 Pad 85/86 Pad	Effects from these facilities are seen cumulatively as occasional cyanide detections and increases in SO_4, TDS, and SC, e.g., L-16	Effects are illustrated in the form of occasional increases in SO_4, TDS and SC ,e.g., ZL-124	Cyanide has been detected in a bedrock well in 1992, otherwise bedrock groundwater appears to be unaffected, e.g., ZL-119

TABLE 3.2-32
EXISTING WATER QUALITY CONDITIONS - SUMMARY
(Continued)

Facility	Surface Water	Groundwater: Alluvium	Groundwater: Bedrock
LANDUSKY			
83 Pad	Effects on surface water illustrated by cyanide detections and extremely high SO_4, TDS and SC although these have improved since 1984, e.g., L-12	No data aailable	Cyanide has been detected in two bedrock wells below the 83 leach pad buttress. Limestones also have elevated TDS and sulfate although pH is neutral e.g., ZL-114R
	Effects from the waste rock dump and 84-85/86 pds appear to be restricted to the surface and alluvial water, this water then meets with surface water draining the 83 pad which also has been impacted by cyanide detection and possible ARD, but has improved substantially since 1988. The surface water sampled as L-2 just above the confluence with Rock Creek appears to be of good quality.		
King Creek			
Montana Gulch Waste Rock Dump August Pit	Neutral pH but moderate levels of TDS and sulfate. Elevated nitrate concentrations, e.g. L-6	Little data available, but neutral pH and moderate levels of TDS and sulfate, e.g. ZL-140	Elevated TDS, sulfate and nitrates but neutral pH, e.g. ZL-139.
	Monitoring record shows surface water to have been only slightly impacted, <u>if at all</u>, at the time ZMI began large-scale mining. Impacts to King Creek during and from historic mining apparently attenuated naturally over many years of inactivity. Nitrate levels are thought to be derived from reclamation efforts in the headwaters or the use of ANFO. Removal of historic tailings during 1993 has reduced the TSS concentration of surface waters.		

TABLE 3.2-32
EXISTING WATER QUALITY CONDITIONS - SUMMARY
(Concluded)

Facility	Surface Water	Groundwater	
		Alluvium	Bedrock
		LANDUSKY	
Swift Gulch			
Queen Rose Pit	Neutral pH and low levels of TDS, sulfate and metals. No cyanide detections	No groundwater data is available.	
	Monitoring record shows the surface waters of South Bighorn Creek to be of good quality and not impacted by present or historic mining activity.		

*Details of examples cited can be found in water chemistry summary tables.

3.3 SOIL AND RECLAMATION

3.3.1 Study Area

Soil of the Zortman and Landusky mining area are developing in two distinct sets of landforms. The first set consists of mountain tops, ridges, sideslopes, and V-shaped valley bottoms within the portion of the study area occupied by the Little Rocky Mountains. Elevations proximate to the study area range from high points of about 5,700 feet above mean sea level (msl) atop Old Scraggy Peak, Antoine Butte, and Shell Butte, to a low point of approximately 4,000 feet above msl at the mouths of Ruby Creek (Zortman), Rock Creek, Mill Gulch, and Montana Gulch (Landusky), where these drainages leave the mountains. Dominant slopes range from approximately 10 percent to over 80 percent (USGS Quads). Slopes greater than 50 percent are common. The presence of V-shaped valleys and the absence of glacial deposits within the mountains indicates that much of the Little Rocky Mountains were not glaciated.

The second set (the remainder of the study area on the Zortman and Landusky side) occurs on the nearly level to gently sloping high plains which extend out from the base of the Little Rocky Mountains. The plains portion of the study area is known as Goslin Flats and the Ruby Flats. Goslin Flats and the Ruby Flats are adjacent broad, nearly level drainage bottoms which contain both Goslin Flats and Ruby Creek. Elevations range from about 4,000 feet at the base of Whitcomb Butte to approximately 3,600 feet at the southern end of the study area. Dominant slopes are less than 8 percent for this portion of the study area. Minor areas with slopes of 8 to 30 percent occur within potential areas of disturbance on the slopes of Whitcomb Butte and side-slopes of higher terraces.

3.3.2 General Soil Description

Soil of the Zortman and Landusky mines area have been mapped and described during a series of soil surveys. Noel and Houlton (1991; ZMI Permit Amendment Application Appendix 3, 1993) compiled all soil mapping and descriptions information for the two mine areas into a summary soil survey document. Previous soil mapping and descriptions addressed in the most recent Noel and Houlton (1991) report include reports by Olsen (1978) and Noel (1983, 1985, 1986, 1988, and 1989). All soil mapping and descriptions developed and presented in the 1991 summary soil survey were conducted in accordance with the National Cooperative Soil Survey using procedures outlined in USDA Handbooks 18, 430, and 436, and unpublished soil survey guidelines provided by the Montana Department of State Lands (DSL 1985).

As described in Noel and Houlton (1991), bodies of soil (soil mapping units) were initially identified and verified in the field using topographic maps and both color and black-and-white aerial photography of the study areas. As part of the field verification of soil units (soil with similar characteristics), profiles of delineated soil units were exposed by excavation at representative sites from the surface to bedrock, to unsuitable salvage material, or to a 60-inch profile depth, whichever was reached first at a sample site. Based on field observations of soil profiles and interpretation of soil and landform relationships, adjoining soil that differed markedly in physical and/or chemical characteristics were delineated into separate units with a minimum size of two acres. Soil that differed slightly in physical and/or chemical characteristics from adjoining soil were delineated to a minimum of five acres in size of discreet soil mapping unit. All horizons of soil profiles determined by field observation to be suitable for salvage and use in reclamation were sampled for subsequent laboratory analyses for soil properties important to the assessment of a soil as a suitable plant growth medium. The assessment of soil characteristics also included the evaluation of soil materials for uses other than cover-soil, growth medium; evaluations for suitability of use as a capillary break, drain layer, liner shield, and clay layer were also completed.

3.3.2.1 Mountain Soil

Soil in the mountainous portions of the study area are predominantly young soil in the early stages of development due to the relatively continuous loss of soil material from rapid runoff on steep slopes (Noel and Houlton 1991). Soil material (less than 2 mm-sized fraction) is weathering from exposed rock surfaces and masses of broken rock deposited by erosion and gravity in rock falls (scree slopes or colluvium). Because of soil loss due to erosion and associated natural sorting, soil textures are gravelly and cobbly sandy loams on the steeper, more unstable slopes; loams on less steep, more stable slopes; and less frequently, clay loams in upland swale bottoms. Parent materials are intrusive igneous rocks, metamorphic rocks, and limestone which are the dominant lithologies of the mountainous features. Drainage bottoms and any low terraces consist of water deposited materials (alluvium) derived from these parent materials. Detailed soil-type mapping, map unit descriptions, site-specific soil profile descriptions, and soil sample analytical results for the mountain and

Goslin Flats soil are presented in Appendix 3 of the Zortman Mine Permit Amendment Application for the Zortman and Landusky mining areas (Noel and Houlton 1991).

3.3.2.2 Goslin Flats and Ruby Flats Soil

Soil of the Goslin Flats portion of the study area are of similar age as the mountain soil. However, they are moderately to well developed, due to reduced slopes (hence, more stable areas) and increased influence from other soil forming factors such as infiltration of water. Predominant soil textures of surface horizons (topsoil) for soil to be salvaged within the footprints of proposed facilities in the Goslin Flats and Ruby Flats areas are loams, silt loams, and clay loams (Noel and Houlton 1991). For soil mostly occupying slopes of 8 percent or less, coarse fragment content (soil particles greater than 2 mm in size including gravel, cobbles, and boulders or rocks) of surface horizons ranges from a trace to 40 percent gravel; however, much of the area and volumes of material have coarse fragment contents of less than 25 percent and soil erodibility factors of approximately 0.40. A soil erodibility factor (K factor) of 0.40 represents a higher inherent erodibility or susceptibility to water erosion.

For soil occupying slopes mostly greater than 8 percent, coarse fragment content ranges from a trace to over 80 percent gravel and cobbles. Soil of much of these steeper areas have coarse fragment contents of 20 to 50 percent and soil erodibility factors of approximately 0.21. A soil K factor of 0.21 represents a lower inherent erodibility (water erosion).

Predominant subsoil horizon textures in the Goslin Flats and Ruby Flats areas are clay loams to clays (Noel and Houlton 1991). Coarse fragment contents of soil on 8 percent or less slopes range from a trace to approximately 60 percent. For soil occupying slopes greater than 8 percent, coarse fragment content of subsoil horizons ranges from a trace to over 85 percent.

Greater infiltration of water in the flats and on terraces (even though textures are more clayey) is due not only to (a) more level surfaces, but also to (b) more soil structure within the surface and subsoil horizons. Soil structure produces spaces between soil aggregates where water can flow down by gravity. The presence of more clayey soil in comparison to the mountain soil is due likely to past transport of weathered fines in streams and deposition in floodplains and terraces. As the streams left the steeper mountains and entered the more level plains, the waters slowed and allowed the fines to settle out in deposits of clayey alluvium. Other possible sources of clay in soil is physical weathering of in-place materials in the surface horizon, air deposition of clay sized particles on the soil surface, and eluviation (i.e., transport by water and gravity from the surface horizon) into subsurface horizons as part of the normal soil formation process.

Coarse fragment content varies among and within soil types, but is more prevalent in colluvium along the edge of the mountains and in the alluvial stream deposits. Parent materials include erosional deposits of alluvium, colluvium and residuum (underlying rocks which are weathering in place to produce soil sized particles) of sandstones and shales (Noel and Houlton 1991).

3.3.3 Soil Reclamation Potential

Issues and concerns raised by agencies and the public during scoping have focused on identifying the availability and capability of the soil resources (a) to withstand impacts from mine development and (b) to provide adequate quantities of appropriate materials for effective, long-term reclamation of affected lands, particularly the waste rock and heap leach materials. The soil is an essential resource, which when properly salvaged, protected, and redistributed, would hasten reclamation and new soil formation.

Undisturbed soil of the Little Rocky Mountain area are likely a minimum of 10,000 years old and have developed since the last major climatic change and major soil disturbance associated with the retreat of the ice sheets and glaciers. The soil has developed to varying degrees distinct layers or horizons in response to climate, weathering of parent materials, erosion and deposition of soil materials, and biological activity including introduction of organic matter from the decay of vegetative litter and plant roots.

Salvaged topsoil (surface horizon) usually have higher organic matter contents, which typically increase productivity. Salvaged subsoil, due to natural sorting and soil development, can have characteristics that can lend themselves to various uses operationally and post-operationally in a selected reclamation cover. The preservation of many of the characteristics of different surface and subsurface horizons by salvage and separate stockpiling lessens the adverse effects of soil disturbance and associated loss of soil development. Salvage of distinct soil layers, storage, and replacement in kind as part of a reclamation program greatly enhances the soil resources' abilities to support protective and productive vegetation for wildlife habitat and visual enhancement.

The reestablishment of a stable soil system and vegetative cover on affected landforms can occur in a matter of a few years, depending on environmental conditions and effectiveness of the implemented reclamation plan. The absence of a reclamation program involving soil salvage, storage, and replacement would waste the previous 10,000 years of soil development. Salvage, storage, and the ordered replacement of soil materials "short-circuits" the time required to reach a higher level of soil development, soil stability, and vegetative productivity comparable to existing, predisturbance conditions.

Based on the qualitative characterization of the soil resource and quantitative analytical data derived from the analysis of on-site soil samples, impact susceptibility and reclamation suitability can be assessed. The following sections describe reclamation potential of various soil in the Little Rocky Mountains.

3.3.3.1 Mountain Soil

Soil occupying steep slopes are frequently susceptible to accelerated water erosion, particularly when disturbed; however, most of the mountain soil situated on steep slopes within the Zortman and Landusky mines area have low to moderate erosion potentials. These soil have a high coarse fragment content, which serves to stabilize the soil-sized fraction and, in some cases, armor the surface; both factors increase resistance to water erosion and soil loss. Over time, the mountain soil have become armored at the surface through the loss of susceptible soil fines to erosion. In addition, most soil are covered, to varying degrees, with protective vegetation which reduce erosive rainfall impact velocities. Roots and organic matter accumulation increase infiltration characteristics into the soil. The development of soil structure, effects of freezing and thawing, plant root growth, and the activity by soil animals reduce soil bulk density. The high coarse fragment content, in combination with (1) mostly coarser soil textures, (2) erosion-resistant vegetation community root patterns, (3) soil structure, and (4) inherent soil water and permeability conditions, results in most of the mountain soil having very low soil erodibility factors (Noel and Houlton 1991, Table 3-3).

3.3.3.2 Goslin Flats and Ruby Flats Soil

The reduced slopes (mostly 0-8 percent) of the Goslin Flats and Ruby Flats portions of the study area would result in mostly low to moderate potentials for accelerated erosion. However, much of the soil material comprising the floodplains and terraces of the flats is highly erodible when disturbed. Should these soil materials be exposed to channelized flows such as new drainage diversions or be placed on over-steepened slopes, accelerated erosion rates, and soil loss from rill and/or gully development could occur.

3.3.4 Soil Suitability and Availability

The amounts of soil available for salvage or redistribution, if already stockpiled, are presented in Table 3.3-1 for both the Zortman and Landusky mine areas. This table shows the volumes of available cover soil (mix of topsoil and subsoil), topsoil and subsoil for existing stockpiles, reclaimed areas, proposed facilities, and soil mining areas.

Volumes of suitable cover soil and subsoil materials were based on the determination of suitability by depth for each of the soil types using a combination of guidance from the DSL (1985), BLM (1992b), soil suitability evaluations in ZMI (1993, Section 3.0, Reclamation Plan [revised], Noel and Houlton, 1991) and professional judgement.

Soil to be disturbed in both Zortman and Landusky mine areas by construction of the linear access/haul roads, conveyor, power line, LAD support areas, drainages, and reclamation access are located principally in the mountainous portion of the study area. Preceding construction of facilities, suitable cover soil material, where encountered, would be salvaged and windrowed or stockpiled adjacent to the facility for subsequent use in reclamation. The salvaged cover soil materials would be protected from contamination and stabilized through the use of interim revegetation and/or erosion control measures for the life of operations.

Primary physical and chemical properties of soil that define its suitability for use as cover soil or subsoil by DSL are slope (less than 2:1), coarse fragment content (less than 50 percent), and organic matter content (greater than 0.5 percent). Regardless of organic matter content, DSL recommends soil salvage to a depth of 60 inches unless slope or coarse fragment content exceed criteria or bedrock is encountered. The BLM (1992a) provides additional suitability criteria for soil pH (greater than 5 and less than 8.5), sodium adsorption ratio (SAR - less than 8), and electrical conductivity (EC, mmhos/cm - less than 7). The preceding DSL and BLM criteria apply mostly to the evaluation of growth-media cover soil. Additional criteria for the design and construction of cover systems involving potential use of subsoil materials are addressed in BLM (1992a) and in

Reclamation Covers

Reclamation covers, or caps, will serve two critical functions at the Zortman/Landusky mines during mine reclamation. ***First,*** and most visibly, the covers will be used over regraded heap leaches, waste repositories and dumps, pit bottoms and benches, and other facilities to provide a ***growth zone for plants.*** Replacement of suitable soil (from native soil salvaged and stockpiled ahead of mining activities, or obtained nearby) promotes the rapid re-establishment of native plants by helping restore soil conditions similar to those present prior to mining. Native seeds and plants are increasingly favored by the regulatory agencies to re-establish wildlife habitat and the forest and range resources that are often disturbed by mining.

Second, and most importantly from an environmental protection standpoint, the cover is a ***protective barrier*** to prevent air and water from reaching zones of covered spent ore or waste rock that can produce acid rock drainage (see the Acid Rock Drainage sidebar on this matter), and other contamination. The various layers and their functions in a multi-layered, extremely protective cap are described below. Any or all of these layers could also contain net neutralizing materials to aid in passive water treatment by raising alkalinity of potential ARD.

Approximate Range (inches)	Cap Layers	Function
	Vegetative	Provides a protective, stabilizing cover which controls erosive effects of raindrop impact, overland flow, and wind erosion, and holds the soil with roots.
8-24	Soil Layer	Provides a suitable growth medium for desired vegetation; soil physicochemical attributes should support a sustained cover of vegetation, and adequate water-holding capacity, and be of sufficient depth to allow for expected, long-term erosion losses.
18-36	Capillary Break	Provides a mostly rocky layer which serves to hold the overlying soil layer, to conduct excess water from the soil layer away as a drainage layer, to retain moisture (when sufficient fines are present) for use by plants which have rooted into this layer, and to prevent or limit any rise of contaminated moisture from any underlying acid-producing materials.
3-6 (sand or gravel) 5 ounce geotextile	Liner Shield	Provides layer of protective padding between the rocky materials of the capillary break layer above and the low hydraulic conductivity or moisture barrier layer below. The shield can be a layer of coarse sand or crushed gravel, or a thick fabric or geotextile which prevents puncture or damage to the underlying moisture barrier or liner. This layer can also provide drainage of excess moisture.
6-24 (clay) 15-20 mil PVC (geomembrane)	Liner	Provides a barrier to the movement of moisture and air down into the underlying waste or previously exposed rock materials, and to the movement of potentially acidic or contaminated moisture up into overlying layers from the underlying waste and rock materials. This layer can consist of a synthetic (hydrocarbon), geomembrane, a layer of compacted clay, or a combination of both.
	Waste/Spent Ore	

Different covers, depths, and layer types and thicknesses may be used on different facilities, based primarily on environmental protection needs, and anticipated effectiveness of a cover system in response to specific site conditions.

Sources: See *Suggested Reading* in the References regarding reclamation covers, their variations, and functions.

TABLE 3.3-1
SOURCES OF COVER SOIL, TOPSOIL, AND SUBSOIL FOR THE ZORTMAN-LANDUSKY MINES COMPLEX

Mine	Material	Source	Available Volume[1] (yd^3)	Comments
Zortman Mine	Cover Soil	Existing Stockpiles[2]	183,000	Stockpiled materials are a mixutre of topsoil and subsoil: North Ruby Saddle (136,000 yd^3, South Ruby Saddle (32,000 yd^3), and 1982 Leach Pad (15,000 yd^3).
	Cover Soil	Reclaimed Areas	80,000	Specific reclaimed areas and associated averages are presented ZMI's 1993 Annual Reclamation Summary Report, Table II (ZMI 1994a).
	Topsoil	Goslin Flats	567,000	Topsoil could be mined from approximately 250 acres in Goslin Flats; the area is currently undisturbed.
	Subsoil	Goslin Flats	2.2 million	Subsoil could be mined from same 250 acres in Goslin Flats.
Landusky Mine	Cover Soil	Existing Stockpiles[2]	2.2 million	Stockpiled materials are a mixture of topsoil and subsoil: Montana Gulch (181,000 yd^3); Gold Bug (75,000 yd^3); August Pit (437,000 yd^3); and Mill Gulch (1,479,000 yd^3).
	Cover Soil	Reclaimed Areas	228,000	Cover soil (8 inches) over 67 acres of Zortman Mine and 147 at Landusky Mine.

[1] Volume available represents best estimate.
[2] See Figure 2.6-1 for locations of the existing cover soil stockpiles.

EPA's seminar publication Design and Construction of RCRA/CERCLA Final Covers (EPA 1991). In the study area, excessive coarse fragments, shallow depth to bedrock, clayey textures, low organic matter content, SAR, EC, slope, and shallow water table are the main factors which may limit availability of suitable cover soil and subsoil.

3.3.4.1 Zortman Mine - Pits and Limestone Quarry

Soil of the proposed mine pits in the mountainous region of the Little Rocky Mountains are relatively young, shallow soil on steep slopes, which are often over 50 percent. Soil types mapped in areas of proposed mine pit extension are characterized by gravelly, very cobbly loam textures, steep slopes, high coarse fragment contents, and shallow soil which preclude soil salvage from the mine pits extension area. Resource value for use as cover soil (growth medium) is limited. In addition, acid neutralization potential is low because of the geology of the ore body.

Soil present at the proposed limestone quarry locations, LS-1 and LS-2, is generally a gravelly loam on 25 - 50 percent slopes. Where slopes permit, soil would be salvaged ahead of limestone mining operations for future reclamation of the quarry. The net neutralization potential of the soil and limestone is high.

3.3.4.2 Zortman Mine - Alder Gulch

The soil types in the Carter and Alder Gulch and Landusky Mine areas are dominated by gravelly and cobbly loams (Noel and Houlton 1991). Most of these are characterized by slopes over 50 percent, and parent rocks which consist of syenite and syenite porphyry. These soil generally have a low soil erodibility characteristics, low water holding capacity, low net neutralization potential, and a high potential for severe runoff and erosion, if disturbed. Steep slopes, high coarse fragment content, and the lack of soil for plant growth (shallow soil) preclude soil salvage from either facility.

3.3.4.3 Goslin Flats and Ruby Flats

The major source of salvageable topsoil and subsoil is the presently undisturbed Goslin Flats, with the other primary sources of cover soil being existing cover soil stockpiles located within the Zortman and Landusky mine areas (Figure 2.5-1, Table 3.3-1).

The dominant soil present at Goslin Flats consist of loams, gravelly loams, and cobbly loams and have predominantly net neutralizing characteristics. Clay loam to clay subsoil could provide a degree of impermeability almost equivalent to mined clay and not have some of the undesirable features such as desiccation upon drying. The parent materials for these soil are alluvium and sedimentary rocks, and slopes are mostly nearly level to gently sloping (less than 8 percent). Coarse fragment content is higher in glacial tills and colluvium, and their associated soil along Ruby Creek.

The soil of Goslin Flats have higher soil erodibility factors, resulting from higher percent contents of silt and fine sand generally, and less coarse fragment content than in the mountain soil. However, soil erosion potential is still low to moderate due to the greatly reduced slopes of the Goslin Flats area. Table 3.3-1 presents the estimated topsoil and subsoil volumes available for salvage beneath the proposed Goslin Flats heap leach pad, plant facilities, and ore handling area and waste rock depository (250 acres).

3.3.4.4 Landusky Mine - Limestone Quarry

Soil present at both the King Creek and Montana Gulch quarries is generally a gravelly loam on 15-40 percent slopes. Salvage of cover soil material ahead of limestone mining operations would occur where slopes permit.

TABLE 3.3-2

SOURCES OF SUITABLE COVER SOIL AND SUBSOIL MATERIALS FOR THE LANDUSKY MINE AREA[1]

	Volume (yd^3)	
	Cover Soil	Subsoil
Existing Stockpiles[1]		
Montana Gulch	181,000	NS
Gold Bug	75,000	NS
August Pit	437,000	NS
Mill Gulch	1,479,000	NS
Reclaimed Areas[2]		
147 acres with a minimum of 8 inches of redistributed cover soil	176,000	
Proposed Facilities		
King Creek Quarry*	8,000	16,000

* Assume 6 inches cover soil and 12 inches of subsoil for 9.7 acre area.

[1] See Figure 2.6-1 for locations of existing cover soil stockpiles.
[2] Specific reclaimed areas and associated acreages are presented in ZMI's 1993 Annual Reclamation Summary Report, Table II (ZMI 1994a).

Source: Zortman Mining, Inc., Revisions to plans for the Landusky Mining Area Permit #00095, 1995.

TABLE 3.3-3

VOLUMES OF SOIL MATERIALS BY TYPE OF USE, ZORTMAN MINE

	Goslin Flats Heap Leach Pad and Ancillary Facilities (yd^3)	Ruby Flats Waste Rock Depository (yd^3)
Cover Soil		
Steeper Slopes[1]	280,000	271,000
Lesser Slopes[2]	309,000	
Subsoil[3]		
Capillary Break[4]	1,335,000	1,637,000
Liner Shield[4]	69,000	
Clay Layer[5]	44,000	

[1] Slopes generally greater than 3:1; higher coarse fragment content and lower (0.21) K factor soils.
[2] Slopes generally less than 3:1; lower coarse fragment content and higher (0.40) K factor soils.
[3] Most subsoil materials are also acid neutralizing.
[4] Subsoil material potentially suitable for use as a capillary break layer and for moisture retention in support of deeper rooted vegetation and erosion resistance due to higher content of stabilizing coarse fragments.
[5] Coarse sands to gravelly subsoil materials used as liner shield would also act as a drainage layer above a geomembrane or clay liner.
[6] Clay loam to clay subsoils could provide a degree of impermeability almost equivalent to mined clay and not have some of the undesirable features such as desiccation upon drying.

3.4 VEGETATION, WETLANDS, AND OTHER WATERS OF THE U.S.

The Little Rocky Mountains are an isolated range in the northern Great Plains of Montana. A wide array of plant communities[1] are found, some of which are unique to the area. This wide array of plant communities can be attributed to the physical diversity of the area (e.g., a wide range of elevational change and the associated climatic variations in temperature, wind and precipitation regimes; parent material diversity leading to different soil types, depths and fertility; and high geologic diversity) and the response to, and time since, past disturbances such as fire, grazing, and drought.

When a change (disturbance) in the physical environment occurs, changes in the types, numbers, and groupings of plant communities and other organisms occupying an area take place, with accompanying changes in certain features of the physical microenvironment. For example, following a forest fire, lodgepole pine is often the first species to occupy the burned area, generally in dense stands. The dense stands create a shaded understory (i.e., a change in the physical micro-environment). Because lodgepole pine is a shade-intolerant species, its own seedlings either cannot survive or grow poorly, while shade-tolerant seedlings of invading species flourish. Over time, the lodgepole pine forest is replaced by another forest community. This process, known as plant succession, is important in the reclamation of mined areas.

When planning for reclamation, it is necessary to understand the vegetation potential and patterns of vegetation development over time. By replacing topsoil and seeding, reclamation can set the stage for and accelerate the plant succession process, thus providing early and increased protection against wind and water erosion, and reduce the time needed to reclaim the site for proposed post-mine land uses.

Numerous vegetation inventories have been conducted in the project area. A general reconnaissance of the area was made by Culwell (1977). Culwell and Ramsden (1978) conducted site-specific baseline inventories. Additional site specific inventories were conducted by Scow (1983) and Scow and Culwell (1986). Culwell et al. (1989) summarized these vegetative inventories. Larsen et al. (1989) and ZMI (1994) reported on revegetation monitoring of mined sites.

[1] Communities are groups of associated plants typically occurring in repeating patterns.

Culwell et al. (1990) collected additional site-specific data and synthesized these previous reports to prepare a comprehensive account of the vegetation in the project area. This information included detailed vegetation baseline maps.

The BLM has summarized region-wide vegetation data in the Judith Valley Phillips Resource Management Plan EIS (BLM 1992b). A listing of rare or endangered plant species and plant communities which might occur in the project area was obtained from the U.S. Fish and Wildlife Service (USFWS), MDFWP, and the Montana Natural Heritage Program (MNHP) (see Section 3.4.5.1). Figure 3.4-1 shows the general vegetation patterns of the Zortman and Landusky mine areas and proposed extension areas, including forested areas, grassland areas, rock outcrops/scree, and disturbed areas (see Figures in Section 2.0 for the location of existing facilities and proposed expansion areas). These patterns are described in the subsections below.

3.4.1 General Vegetative Patterns

Vegetation is typically described in terms of plant communities. A total of some 25 community types have been identified in the project and surrounding area (see Figure 3.4-1 for vegetation study area boundary). This seemingly large number reflects the environmental diversity encountered. The community types are listed in Table 3.4-1. The acres of vegetation by community type in the Little Rocky Mountains study area are as follows:

Community	Acres
Grasslands	2,700
Shrubland	800
Lodgepole Pine Forest	7,300
Ponderosa Pine Forest	300
Douglas Fir Forest	300
Deciduous Forest	1,300
Rock/Scree/Disturbed	1,700
Total Acres in Study Area	14,400

A detailed description of each community type is included in the vegetation resources report by Culwell et al. (1990), along with data on production, density, cover, and environmental characteristics for each community type. The report also includes a species list for the Little Rocky Mountains study area including common and scientific names and a community type/habitat type correlation.

The Little Rocky Mountains are islands isolated in a sea of northern great plains grasslands. Gentle slopes with variable aspect support a foothills/mixed-prairie

TABLE 3.4-1
VEGETATION COMMUNITY TYPES
LITTLE ROCKY MOUNTAIN STUDY AREA

Grassland Types
- Foothills Mixed Prairie
- Montane Grassland
- Seral Grass/Shrub
- Mesic Grassland

Shrubland Types
- Skunkbush Sumac/Grassland
- Big Sagebrush/Grassland
- Silver Sagebrush/Grassland
- Western Snowberry Drainage Bottom
- Chokecherry Sidehill/Bottom
- Columbia Hawthorne Thicket

Lodgepole Pine Forest Types
- Lodgepole Pine Scree
- Lodgepole Pine/Common Juniper
- Lodgepole Pine/Bearberry (aka kinnikinnick)
- Lodgepole Pine/Mixed Shrub
- Lodgepole Pine/Twinflower
- Recently burned Lodgepole Pine

Ponderosa Pine Forest Types
- Ponderosa Pine/Grass
- Ponderosa Pine/Creeping Juniper
- Ponderosa Pine/Western Snowberry
- Ponderosa Pine/Common Juniper
- Ponderosa Pine/Bearberry (aka kinnikinnick)
- Ponderosa Pine/Oregon Grape

Douglas-Fir Forest Types
- Douglas-fir/Western Snowberry
- Douglas-fir/Bearberry (aka kinnikinnick)
- Douglas-fir/Twinflower
- Douglas-fir/Oregon Grape

Deciduous Tree Woodland
- Quaking Aspen/Paper Birch

Source: Culwell et al. 1990

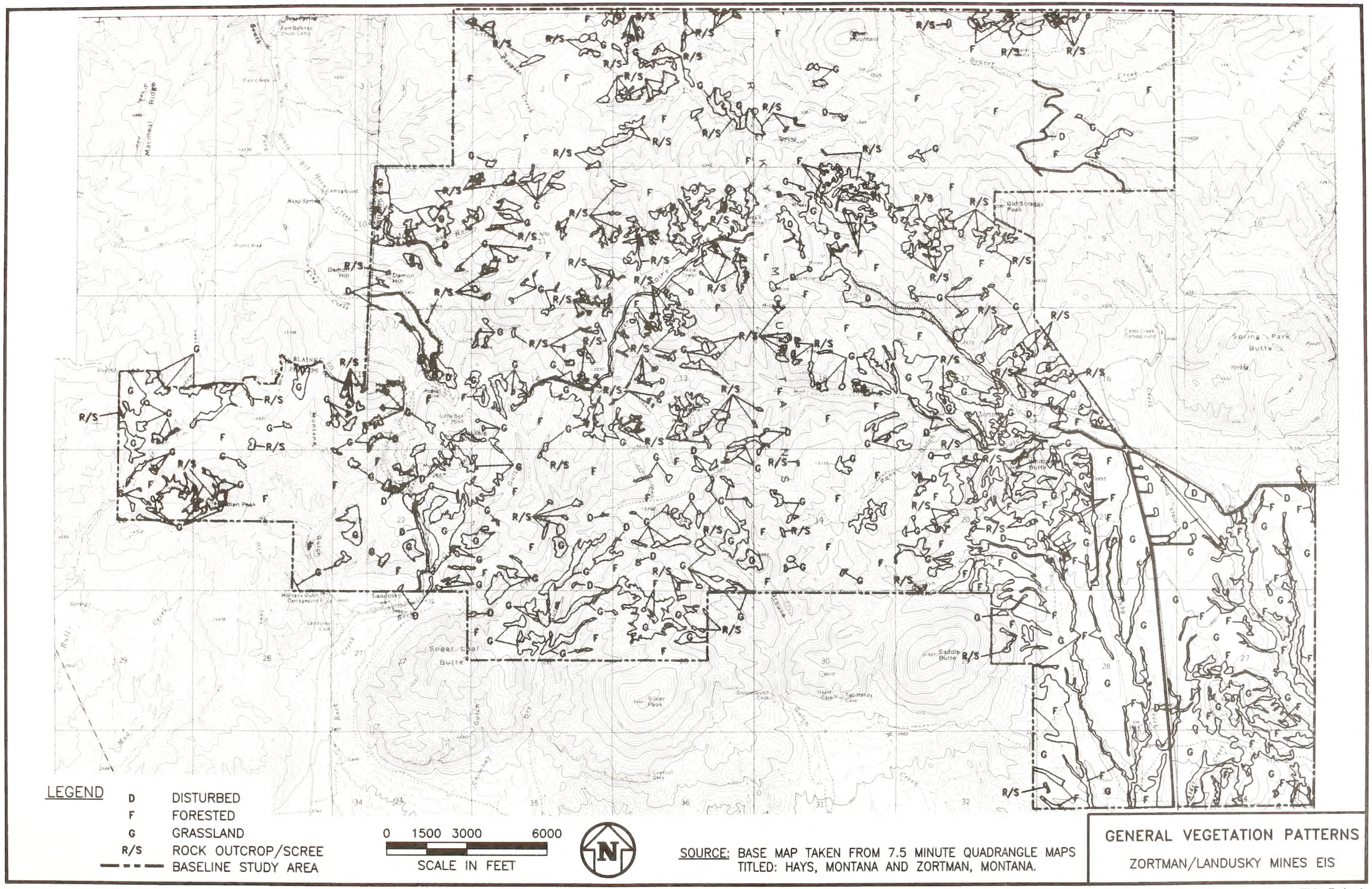

LEGEND
D DISTURBED
F FORESTED
G GRASSLAND
R/S ROCK OUTCROP/SCREE
BASELINE STUDY AREA
0 1500 3000 6000
SCALE IN FEET
N
SOURCE: BASE MAP TAKEN FROM 7.5 MINUTE QUADRANGLE MAPS TITLED: HAYS, MONTANA AND ZORTMAN, MONTANA.
GENERAL VEGETATION PATTERNS
ZORTMAN/LANDUSKY MINES EIS

FIG. 3.4–1

community type dominated by various dryland grasses. Various shrubland types dominate the lower drainage bottoms and occur on steep sidehills leading into the mountains. Several dry south-facing sidehill slopes and draws radiating from the mountains contain ponderosa pine forest types. Broad moist draws contain substantial stands of quaking aspen/paper birch. Low elevation, north-facing slopes contain stands of Douglas-fir. Lodgepole pine types dominate the majority of the area. Most stands are dense as a result of past recurrent wild fires.

Vegetation in the immediate area of the Zortman mine ranges from a western snowberry shrubland community at 3,500 feet in elevation in Ruby Gulch to a lodgepole pine/scree community at 5,700 feet on Shell Butte and Scraggy Peak. Community types found at the Goslin Flats area consist primarily of foothills mixed prairie grasslands and Columbia hawthorn shrublands intermixed with smaller plots of big sagebrush and silver sagebrush communities. Alder Gulch consists of several community types. At the mouth of the Alder Gulch drainage, quaking aspen/paper birch and Douglas-fir/twinflower communities dominate the surroundings. Ponderosa pine communities are found on south-facing sidehill slopes and draws radiating from the drainage floor. Recently burned lodgepole pine and lodgepole pine/scree communities are found in the upper elevations at the head of Alder Gulch.

Vegetation in the immediate area of the Landusky mine consists mainly of forested community types. Ponderosa pine/bearberry (also known as kinnikinnick) and ponderosa pine/Oregon grape community types are common on the south side of Landusky mine, intermixed with montane grasslands. Douglas-fir/twinberry and quaking aspen/paper birch community types are found in the drainages. On the north side of the mine, lodgepole pine community types are more common, including lodgepole pine/mixed-shrub and lodgepole pine/twinflower.

A substantial area in the Little Rocky Mountains was burned by a forest fire in 1936. Smaller fires burned additional areas in 1984 and 1988. Lodgepole pine, a pioneer species, was quick to invade burned sites. Douglas-fir and ponderosa pine are invading many of the lodgepole stands and, without further disturbance, most of the area would likely support climax stands of Douglas-fir and ponderosa pine. Fire would likely continue to be a major ecological factor shaping this environment, resulting in early to mid-seral community types as the dominants. ("Seral" refers to the series of stages that follow one another in ecological succession.)

Historic and current mining-related disturbances occur in the Little Rocky Mountains. Approximately 401 acres have been disturbed by the existing Zortman operations, and approximately 814 acres by the Landusky operations. Past and ongoing reclamation efforts have included both interim and final reclamation measures. Interim revegetation (i.e., the stabilization of an area vegetatively prior to final reclamation) has been performed to meet short-term objectives to control erosion, sedimentation, and noxious weeds on stockpiles and cut-and-fill slopes. Final reclamation is performed at the completion of operations or concurrently with operations.

3.4.2 Forestry

Approximately 15,000 productive forested acres of BLM land exist in the Little Rocky Mountains, in addition to 29,360 acres of public and private merchantable timber on tribal lands (Spencer 1994), and an indeterminate number of acres of private productive forested land. Past and present demand for forest products from the Little Rocky Mountains has been locally significant. Forest products include house logs, corral poles, fence posts, Christmas trees, fuelwood, and limited sawtimber. Native American uses for timber resources include tipi poles (lodgepole pine), Sundance lodges (cottonwood), as well as ceremonial and medicinal uses (see "Spiritual and Physical Characteristics of the Little Rocky Mountains" in Section 3.12.4.3).

The commercial timber species from the area are lodgepole pine, ponderosa pine, and Douglas-fir. Based on information collected during the 1978, 1983, and 1985 inventories, most lodgepole pine were found to be even-aged stands ranging from 40 to 55 years old, 3 to 10 inches in diameter and 20 to 40 feet high. Yield capability for lodgepole pine, as determined by Roberts and Sibbernsen (1978), ranged from 20 - 41 ft^3/acre/year. The ponderosa pine stands were generally found to be older than the lodgepole pine stands, ranging from 120 to 150 years old with a few recorded trees over 200 years old. Other ponderosa pine stands are less than 80 years old. Diameters and heights of ponderosa pine were quite variable, reflecting an uneven-aged stand structure. Yield capability for ponderosa pine and Douglas-fir ranged from 19 to 68 ft^3/acre/year and 22 to 52 ft^3/acre/year, respectively (Roberts and Sibbernsen 1978).

The volume of lodgepole pine and ponderosa pine in the Little Rocky Mountains is estimated to be approximately 2.9 thousand board feet (MBF) per acre. This estimate, however, is based on a small sample area from a recent timber sale, and actual volumes will vary from stand to

stand. Many areas may contain volumes much higher or much lower (Reid 1994). There are no recent volume estimates for other wood products such as posts, poles and firewood.

A forest analysis is provided in the vegetation resources report (Culwell et al. 1990), which includes data on tree density, diameter, height, age, site index, and yield capability by community type, and information on fire history.

3.4.3 Riparian Areas, Wetlands and Other Waters of the U.S.

3.4.3.1 Riparian Vegetation

Numerous streams and ephemeral creeks occur throughout the project area in moist drainage bottoms, and several springs are present in the alluvium. These riparian areas do not qualify as wetlands based on the criteria in Section 3.4.3.2. Generally, these "non-wetland" areas lack the hydric soil component necessary to qualify as a jurisdictional wetland (Culwell et al. 1992).

A review of the vegetation maps accompanying the 1990 vegetation resource survey (Culwell et al. 1992) shows the following community types are most commonly found in riparian areas:

- Quaking Aspen/Paper Birch
- Western Snowberry Drainage Bottom
- Columbia Hawthorne Thicket
- Chokecherry Sidehill/Bottom
- Mesic Grassland

For example, Alder Gulch, which has a more extensive riparian zone than the other drainages in the study area, contains mostly quaking aspen/paper birch and Douglas fir/twinflower communities. In the aspen/birch community type, understory shrub cover can average from 28-53 percent and consist of spirea, snowberry, chokecherry, rose and willow. Subshrub cover is dominated by twinflower and creeping Oregon-grape. Important forbs include spreading dogbane, showy aster, northern bedstraw, heartleaf arniea, cow parsnip, Canada goldenrod, western meadowrue, and Canada violet (Culwell et al. 1990).

3.4.3.2 Jurisdictional Wetlands

The value of wetlands and the need for their protection have recently risen to the forefront in vegetation management. Wetlands play a major role in water quantity and quality, serving as buffers for floods and as natural filters for sediments and pollutants. Wetlands are highly productive natural biological systems that provide abundant and diverse habitat for plants and animals. Recent legislation for wetlands has focused on minimizing or mitigating human impacts on these areas.

Wetlands and other "waters of the United States" are regulated by the Corps of Engineers (COE) with program oversight by EPA and are subject to Section 404 of the Clean Water Act. "Waters of the U.S." has a broad meaning that includes, but is not limited to, lakes, streams, and rivers, including their adjacent wetlands and tributaries which are or have been used for interstate commerce; navigable waters; interstate waters; intermittent drainages; and any other waters, the degradation of which could affect interstate commerce. To be defined as a jurisdictional wetland a site must meet positive criteria in three areas including: (1) prevalence of hydrophytic vegetation, (2) hydric soil, and (3) wetland hydrology. Non-wetland waters of the U.S. are defined as incised drainages with defined beds and banks which do not meet all these criteria. Jurisdictional waters of the U.S. within the study area include vegetated wetlands, and drainages or waterways.

Wetlands within the project study area were inventoried in 1991 and 1992 (Culwell et al. 1992). Investigations to evaluate wetland criteria were performed in consideration of both the 1987 and 1989 COE wetland delineation manuals. Most of the onsite survey work was conducted using the 1989 Federal Manual for Identifying and Delineating Jurisdictional Wetlands (FICWD 1989), since field work predated the 1992 Energy and Water Development Appropriation Act amendment of 1992 prohibiting its use. Data and mapping were adapted to criteria set forth in the 1987 COE Manual (Environmental Laboratory 1987). The report is summarized below.

Wetland Criteria

Hydrophytic Vegetation

Hydrophytic vegetation is plant life growing in water or on a substrate that is periodically saturated and deficient in oxygen as a result of excessive water content. Hydrophytic vegetation has the ability to grow, compete, reproduce, and persist in anaerobic soil conditions. A USFWS (Reed 1988) list of plant species that occur in

wetlands, specific to Montana, was utilized for the wetlands survey.

Stands in the study area dominated by Nebraska sedge, common spikebrush, cattail, or beaked sedge meet COE criteria for hydrophytic vegetation. These types are narrowly restricted to drainages, generally at lower elevations in the study area. In addition, one aspen stand and one small stand of Bebb willow in Camp Creek met COE criteria for hydrophytic vegetation.

Hydric Soil

Hydric soil is soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions, usually for one week or more during the growing season. Typically, the soil is poorly to very poorly drained. Site-specific hydric soil investigations were conducted using soil surveys, aerial photographs, USGS maps, and vegetation and hydrological data. These data were compiled and then verified in the field by digging shallow pits and noting hydric indicators.

Wetland Hydrology

An area is considered to have wetland hydrology when saturated to the surface or inundated, either permanently or periodically, during the growing season for one week or more. The wetland hydrology of a site is influenced by precipitation, stratigraphy, topography, soil permeability, and plant cover. Due to the variability of these influences, wetland hydrology can be difficult to determine. Water resource baseline data for the project area and field investigations were used to delineate areas meeting wetland hydrology criteria.

A minimum of one positive wetland indicator from each parameter (vegetation, soil, and hydrology) must be found in order to make a positive wetland determination.

Study Area Wetlands

Jurisdictional wetlands in the study area include palustrine and riverine habitat systems as defined by the National Wetland Inventory classification (Cowardin et al. 1979). Palustrine wetlands are the most abundant habitat type in the study area. The classification includes wet meadows, marshes and willow shrublands dominated by persistent emergents and shrubs. The most common wetland plant community identified in the study area is dominated by herbaceous species, including Nebraska sedge, Baltic rush, common spikerush, beaked sedge, common horsetail and cattail. A small shrub-dominated wetland (Bebb willow) occurs in Camp Creek. These wetland areas are generally restricted to drainage bottoms, alluvial deposits where stream currents are reduced and spring/seep areas.

Riverine wetlands are those contained within a channel that is not dominated by vegetation. This wetland type is associated with perennial and intermittent streams in the study area. There are approximately 21.8 acres of wetland identified in the study area. Approximately 12.8 acres are associated with the following drainages in the Zortman project area: Ruby Gulch, Alder Gulch, Goslin Flats, Lodgepole Creek, Beaver Creek and Camp Creek. Approximately 9.0 acres of wetlands are associated with the following drainages in the Landusky project area: Rock Creek, Mill Gulch, Montana Gulch, King Creek, South Bighorn Creek, and Bull Creek. Refer to Table 3.4-2 for a summary of the wetland type by drainage. The table describes the type of wetland(s) present and the characteristics of the wetland(s). For example, the wetlands in Goslin Flats are small, discontinuous palustrine wetlands (marshes and shrub wetlands) fed by springs, with some overgrazed areas around ponds. The Alder Gulch area contains only a small amount of jurisdictional wetland (0.26 acres) consisting of both palustrine and riverine type communities. (Alder Gulch does have a large non-wetland riparian area; see Section 3.4.3.1). Figure 3.4-2 identifies the approximate location of the jurisdictional areas. No impacts to jurisdictional wetlands have been identified from past or existing mining activities. This is based on recollections of individuals familiar with the area prior to disturbance, and review of pre-disturbance aerial photographs.

3.4.3.3 Jurisdictional Non-Wetland Waters of the United States

Many portions of the drainages may exhibit wetland hydrology as defined by the COE; however, the wetland criteria for hydric soil and/or hydrophytic vegetation may not be present due to the steep stream gradients, incised channels, rapid runoff and coarse textured alluvial materials. These drainages are considered jurisdictional non-wetland waters of the U.S., and include many of the perennial and intermittent drainages and tributaries in the study area. The location of non-wetland waters of the U.S. within the study area was determined for inclusion in the September 1995 404 permit applications.

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ZOR-JWET

JURISDICTIONAL WETLANDS
FUNCTIONS AND VALUES ASSESSMENT
ZORTMAN/LANDUSKY MINES

FIG. 3.4-2

TABLE 3.4-2
SUMMARY OF EXISTING WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA

Drainage	**Dominant (D)/ Subdominant (S) Wetland System Total Acres (Site Numbers)****	**Overall Rating*** Effectiveness/ Opportunity**	**Functions and Values Provided at Moderate (M) to High (H) Level for Effectiveness, Opportunity, or Social Significance: Those Not Listed Would be Low***	**<u>Rationale</u>: Attributes listed or comment given briefly explains why the function or value was rated accordingly.**
ZORTMAN				
Ruby Gulch below the town of Zortman	Palustrine (D) 0.64 ac (#8, 9, part of 6)	Low	Hydrologic Support (H)	Extent of wetlands is negligible; upstream channel system has been altered; springs/seeps create one perennial wetland (in side trib); stockwater is a beneficial use.
Ruby Gulch above the town of Zortman	Palustrine (D) Riverine (S) 0.44 ac (#10, 11)	Low	Hydrologic Support (H) Floodflow Alteration (M) Aquatic Diversity/Abundance (M)	Wetlands occur only in side tributaries to Ruby Gulch. Extent of wetlands is small but occurs in 100-year floodplain; dominated by forest/shrub cover; high gradient system. No fishery but macroinvertebrate community intact in side tributaries.
Alder Gulch below the town of Zortman	–	–	None	No wetlands delineated; system has been altered.
Alder Gulch above the town of Zortman	Palustrine (D) Riverine (S) 0.26 ac (#15, 16)	Low	Floodflow Alteration (M) Sediment Stabilization (M) Water Purification (M) Wildlife Diversity/Abundance (M)	Two small wetlands with large receiving area; man-made dam/old pond provides some flow reduction. Receives periodic sediment flushes from naturally eroding slopes in headwaters. Wetland atypically wide; may receive bank overflow during peak runoff. Provides habitat diversity and interspersion.
Goslin Flats	Palustrine (D) 1.8 ac (#1, 2, 3, 4, 5a, 5b, 5c, part of 6, 7)	Low	Hydrologic Support (H) Floodflow Alteration (M) Water purification (M) Sediment Stabilization (M)	Springs/seeps create perennial wetlands. Extent of wetlands is small and channel connections discontinuous but stockponds (which are non-wetland waters) create constricted outlets. Vegetative cover is intact with exceptions of overgrazed/trampled areas around ponds.

TABLE 3.4-2
SUMMARY OF EXISTING WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Wetland System Total Acres (Site Numbers)**	Overall Rating*** Effectiveness/ Opportunity	Functions and Values Provided at Moderate (M) to High (H) Level for Effectiveness, Opportunity, or Social Significance: Those Not Listed Would be Low*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Lodgepole Creek	Palustrine (D) Riverine (S) 1.0 ac (#30, 30a, 30b, 30c)	Moderate	Hydrologic Support (H)	Springs/seep create perennial wetlands.
			Floodflow Alteration (M)	Wetland area within the 100-year floodplain; forested/shrub wetland communities comprise >30% of wetland area.
			Wildlife Diversity/Abundance (M)	Habitat diversity is moderately high.
			Aquatic Diversity/Abundance (M)	Habitat dispersion and plant richness is high; good fish cover; intact macroinvertibrate community (brook trout present in lower drainage off study area).
			Uniqueness/Heritage (M)	Intact wetland/stream system with few perturbations.
			Water Purification (M)	Wetlands are extensive in comparison to other drainages; often have organic soil and emergent communities to buffer/attenuate inputs; pollutant input low (primarily sediments).
Beaver Creek	Palustrine (D) Riverine (S) 1.1 ac (#33, 34, 35, 36, 37, 38, 39)	High	Hydrologic Support (H)	Springs/seeps create perennial wetlands.
			Floodflow Alteration (H)	Wetlands area within the 100-year floodplain; forested/shrub wetland communities comprise >30% of wetland area; series of active beaver ponds create outlet constriction.
			Sediment Stabilization (M)	Wetlands can buffer erosive forces and sediment inputs.
			Wildlife Diversity/Abundance (M)	Habitat diversity is moderately high.
			Aquatic Diversity/Abundance (H)	Habitat dispersion and plant richness is high; good fish cover; intact macroinvertebrate community; brook trout present.
			Uniqueness/Heritage (M)	Intact wetland/stream system with few perturbations.
Camp Creek	Palustrine (D) 7.5 ac (#12, 13a, 13b, 13c, 14)	Moderate (Low end)	Hydrologic Support (H)	Springs/seeps create perennial wetlands.
			Floodflow Alteration (M)	Wetlands area within the 100-year flood plain; wetland areas wide.
			Sediment Stabilization (M)	Wetlands can buffer erosive forces and sediment inputs; receives some sediment.
			Wildlife Diversity/Abundance (M)	Habitat diversity is moderate.

TABLE 3.4-2
SUMMARY OF EXISTING WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Wetland System Total Acres (Site Numbers)**	Overall Rating*** Effectiveness/ Opportunity	Functions and Values Provided at Moderate (M) to High (H) Level for Effectiveness, Opportunity, or Social Significance: Those Not Listed Would be Low*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
LANDUSKY				
Rock Creek/ Sullivan Gulch	Palustrine (D) Riverine (S) 0.24 ac (#26, 27, 28, 29)	Low	Hydrologic Support (H) Floodflow Alteration (M) Sediment Stabilization (M) Wildlife Diversity/Abundance (M)	Springs/seeps create perennial wetlands. Wetlands area within the 100-year floodplain; wetland areas wide. Wetlands can buffer erosive forces and sediment inputs; receives some sediment. Habitat diversity is moderate. Aquatic habitat may have been impaired upper end by ARD originating from buttress of 91 (Sullivan Park) leach pad or underlying disturbances; flow ephemeral in upper part.
Mill Gulch	Palustrine (D) Riverine (S) 0.1 ac (#24, 25)	Very Low		Aquatic habitat may have been impaired by ARD and cyanide/87/91 leach pad and possibly from cyanide spills in the head of the western tributary to Mill Gulch; ephemeral/intermittent stream flows.
Rock Creek below Montana Gulch	Palustrine (D) Riverine (S) 2.8 ac (#31)	Low (High end)	Sediment Stabilization (M) Water Purification (H) Aquatic Diversity/Abundance (M)	Wetlands can buffer erosive forces and sediment inputs; receives some sediment. Wetlands have some organic soils and emergent communities to buffer/attenuate inputs; pollutant input from sediments low, slight increase in sulfate and TDS since 1979. Supports non-salmonid fishery in perennial reaches and "off-site" reservoirs.
Montana Gulch	Palustrine (D) Riverine (S) 0.89 ac (#22, 22a, 22b, 22c, 23, 23a, 23b, 23c)	Moderate (Low End)	Hydrologic Support (H) Floodflow alteration (M) Sediment Stabilization (M) Wildlife Diversity/Abundance (M)	Springs/seeps create perennial wetlands. Wetlands area within the 100-year floodplain; wetland areas wide. Wetlands can buffer erosive forces and sediment inputs; receives some sediment. Habitat diversity is moderate; somewhat reduced by development. Aquatic habitat may have been impaired by ARD from historic/current discharges from Gold Bug Adit and ARD and cyanide associated with 83, 85/86.

TABLE 3.4-2
SUMMARY OF EXISTING WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Wetland System Total Acres (Site Numbers)**	Overall Rating*** Effectiveness/ Opportunity	Functions and Values Provided at Moderate (M) to High (H) Level for Effectiveness, Opportunity, or Social Significance: Those Not Listed Would be Low*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
LANDUSKY				
King Creek	Palustrine (D) Riverine (S) 1.2 ac (#17, 18, 19, 20)	Moderate (High end)	Hydrologic Support (H)	Springs/seeps create perennial wetlands.
			Floodflow Alteration (H)	Wetlands area within the 100-year floodplain; wetland areas wide.
			Sediment Stabilization (M)	Wetlands can buffer erosive forces and sediment inputs, possibly nitrates; receives sediment; active beaver.
			Water Purification (H)	
			Production Export (H)	
			Wildlife Diversity/Abundance (M)	Habitat diversity is moderate; somewhat reduced by development; other indicators rated moderate.
			Aquatic Diversity/Abundance (M)	Permanently flooded with aquatic bed habitat and 3 or more communities.
			Uniqueness/Heritage/Recreation (M)	Used for recreational and traditional cultural practices.
South Bighorn/ Swift Gulch	Palustrine (D) Riverine (S) 2.1 ac (#21, 40, 41)	Moderate	Hydrologic Support (H)	Springs/seeps create perennial wetlands.
			Floodflow Alteration (M)	Wetlands area within the 100-year floodplain; wetland areas wide.
			Sediment Stabilization (M)	Wetlands can buffer erosive forces and sediment inputs.
			Aquatic Diversity/Abundance (M)	Habitat dispersion and plant richness is high; good fish cover; intact macroinvertebrate.
			Wildlife Diversity/Abundance (M)	Habitat diversity is moderate.
Bull Creek	Palustrine (D) Riverine (S) 1.7 ac (#32)	Moderate (High end)	Hydrologic Support (H)	Springs/seeps create perennial wetlands.
			Floodflow Alteration (M)	Wetlands area within the 100-year floodplain; wetland areas wide.
			Sediment Stabilization (H)	Wetlands can buffer erosive forces and sediment inputs; receives sediment; active beaver.
			Wildlife Diversity/Abundance (H)	Habitat diversity is moderate; somewhat reduced by development; other indicators ranked high.
			Aquatic Diversity/Abundance (M)	Habitat dispersion and plant richness is high; good fish cover; intact macroinvertebrate.

TABLE 3.4-2
SUMMARY OF EXISTING WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA
(Concluded)

***NOTES:**

This rating combines the score identified for each wetland (for each function/value rated) within the drainage.
Functions and values evaluated
Hydrologic Support (Groundwater Discharge and/or Recharge)
Floodflow Alteration
Sediment Stabilization/Erosion Control
Water Purification (Sediment Transport/Toxicant Reduction; Nutrient Removal/Transformation)
Production Export/Food Chain Support
Aquatic Diversity/Abundance
Wildlife Diversity/Abundance (Breeding, Migration, and/or wintering)
Threatened, Endangered, or Sensitive (TES) Species Habitat
Uniqueness/Heritage/Recreation

**Wetland system after Cowardin (1979); acreages were estimated unless noted on 404 Permit (1995) maps; study area boundary is the same as that used for the wetlands inventory; wetland sites (assigned by OEA Research, Inc.) shown on Figure 3.4-2

***The overall rating takes into account each wetland score and combines them into an overall rating wetlands that may occur (not site specific) in the drainage; each site was evaluated using a modified Adamus et. al. (1991) probability analysis (EA Engineering Science and Technology 1992); known conditions were gathered from site visits in June 1995; PDEIS and ZMI baseline reports and communications with EIS team specialists were used to "fine-tune" the rating, which combines all functions and values rated; site detail is provided in the Wetland Functions and Values Report found in EIS project file

Source: OEA Research, Inc., Helena, MT, July 15, 1995; revised January and March 1996

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3.4.3.4 Functions and Values

The wetlands and waters of the U.S. within the project area are recognized as providing several important functions and values. The assessment of the functions and values of wetlands was based primarily on a modified approach of the Wetland Evaluation Technique (WET II) adapted for another mine site in Montana (EA Engineering, Science & Technology 1992). The social significance values (uniqueness, heritage and recreation) were evaluated using WET II (Adamus et al. 1991). In addition, best professional judgement based on site visits and available literature were also used in this assessment. Hydrologic support (groundwater discharge), flood flow alteration, sediment stabilization, and aquatic and wildlife diversity/abundance are considered to be the most important functions of the wetlands in the project site. Table 3.4-2 provides a summary of the existing wetland functions and values for each drainage area.

An assessment of the functions and values of the non-wetland waters of the U.S. within the project area is provided in Table 3.4-3. This information represents current (existing) conditions and is based on the data presented in the water resources, wildlife, recreation, and cultural resources sections of this document. To date, mining activities have directly impacted 3.73 acres of non-wetland waters (fill) and indirectly impacted approximately 14.6 acres of non-wetland waters in the project area. The 14.6 acres of indirect impacts represents an estimate provided by the COE of the area of the downstream drainages that have been impacted through reduced water quality (as indicated by monitoring data) due to mining activities since 1990 (COE, Internal Memo, 1995). Table 3.4-3 reflects the current conditions and therefore the effects of these past direct and indirect impacts. Where past impacts can be attributed to actions that occurred from 1990-1995, this is noted in the table. Changes from 1979 to the present are described instead, if impacts during 1990-1995 could not be clearly identified from available data.

Project impacts that may affect the functions and values of wetlands and non-wetlands waters of the U.S. are addressed in Section 4.4 and in the Preliminary Clean Water Act Section 404(b)(1) evaluation in accordance with the COE regulations (refer to Appendix B.) The 404(b)(1) analysis evaluates the potential adverse impacts in human use characteristics (i.e., water supplies, recreation, aesthetics) and physical, chemical and biological characteristics. Practical and appropriate steps to minimize potential impacts are also evaluated.

3.4.4 Noxious Weeds

Noxious weeds are an important local concern due to their impacts on agriculture production and native plant communities. Phillips County has an active weed control program to prevent the spread of and to eradicate noxious weeds as much as possible.

The Montana Noxious Weed Control Act (1991) identifies ten Category 1 noxious weed species. Category 1 noxious weeds are weeds that are currently established and widespread in many counties of the state. These weeds are capable of rapid spread and render land unfit or greatly limit beneficial uses.

Currently, six of the ten Category 1 weeds are listed on the noxious weed list for Phillips County (Williams 1995). They are:

1. Canada thistle *(Cirsium arvense)*
2. Leafy spurge *(Euphorbia esula)*
3. Russian knapweed *(Centaurea repens)*
4. Whitetop *(Cardaria draba)*
5. Field bindweed *(Convolvulus arvensis)*
6. Spotted knapweed *(Centaurea maculosa)*

All of these weeds could potentially occur within the project area; however, Canada thistle, and spotted knapweed are the only species observed during vegetation surveys conducted in the project vicinity. Trace values were recorded for Canada thistle, and spotted knapweed was observed along roadsides and upland sites in the vicinity of the mine (name of the mine not specified) (Culwell et al. 1990).

To prevent the spread of noxious weeds, ZMI developed a weed control plan that has been reviewed by the Phillips County Weed Management Program which outlines specific procedures for control of noxious weeds on mine property. ZMI would control noxious weeds by mechanical methods or chemical application by licensed personnel. ZMI would control and monitor noxious weed populations throughout the life of the mine and post-closure until the reclamation bond is released.

Other weed species, though not officially designated as noxious, are of local concern. These "weedy" species are houndstongue *(Cynoglossum officinale)*, Japanese brome *(Bromus japonicus)*, burdock *(Arctium sp.)*, musk thistle *(Carduus nutans)*, cheatgrass brome *(Bromus tectorum)*, and dalmation toadflax *(Linaria dalmatica)*. Disturbed sites throughout the area can provide suitable habitat for the invasion of noxious weeds. Noxious weed invasion is inevitable and cannot be entirely prevented.

3.4.5 Species of Special Concern

Species of special concern include those species listed as endangered or threatened by the USFWS, those under review (Category 1 and 2) for endangered or threatened status, those species of special interest or concern as listed by the MDFWP or the BLM, those species considered critically imperiled or imperiled by the MNHP, and any species receiving substantial public comment during the scoping period.

3.4.5.1 Threatened, Endangered, or Sensitive Species and Communities

No plants listed as threatened or endangered under the Endangered Species Act or as of special interest or concern by the MDFWP or the BLM are known to occur within the project area (BLM 1992b, USFWS 1993, MDFWP 1993). Additionally, the MNHP lists no rare plant communities in the project area (Cooper 1995).

Groundsel (*Senecio eremophilus*) is the only plant species listed as a species of special concern by the MNHP that may potentially occur in the project area. This plant was collected during the 1978 inventory on a rocky, historic mining road near the saddle at the head of Ruby Gulch. Additional specimens have not been noted during subsequent vegetation inventories (Culwell et al. 1990).

The MNHP status of *Senecio eremophilus* is "G4S1," which is defined as follows:

G4 Apparently secure globally, though it might be quite rare in parts of its range, especially at its periphery.

S1 Critically imperiled in Montana because of extreme rarity (5 or fewer occurrences, or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extirpation from the state.

The MNHP identified four occurrences of the ponderosa pine/bearberry (aka kinnikinnick) plant association in the Zortman/Landusky area (see Figure 3.4-2). The status of this association is "G5S3," which is defined as follows:

G5 Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery.

S3 Either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range, or vulnerable to extinction throughout its range because of other factors; in the range of 21 to 100 occurrences.

Previously, the MNHP had identified two rare communities on Saddle Butte, a ponderosa pine/bluebunch wheatgrass association and a Douglas-fir/little bluestem association. Upon further evaluation, the MNHP determined the ponderosa pine/bluebunch wheatgrass association to be a relatively common plant community and removed it from their list. Also, the Douglas-fir/little bluestem association has been re-defined as a minor seral association and will be removed from the next MNHP State Classification list, as well as the Western Region Classification list (Cooper 1995).

3.4.5.2 Ethnobotany

The Little Rocky Mountains have historically been and continue to be a source of plant materials for ethnobotanical uses. The term ethnobotany refers to the study of the uses of plants by different races of man. Numerous public comments were received concerning plants that occur near the project area and may be used by Native Americans for religious, medicinal, food, and shelter purposes. Deaver and Kooistra (1992) identified 29 species that are used in local traditional culture. Culwell et al. (1990) lists 200 species which are documented for ethnobotanical use.

Of the 29 plant species identified by Deaver and Kooistra (1992) as being utilized by the Native Americans at Fort Belknap, 23 species were documented by Lutwel (1990) as being present within the study area (see Table 3.12-2). Many of the plants, such as snowberry, chokecherry, juniper, bearberry, Oregon grape, wild rose, sage, and all of the tree species, are abundant throughout the study area. Approximately 50 percent of the species identified by Deaver and Kooistra (1992) were reported to occur in the project area; however, relative abundance was not recorded. Documentation is not available regarding the location of any preferred sites for the collection of plant material used by the Native Americans. Six of the plants identified in Deaver and Kooistra (1992) were not reported to occur in the study area. In particular, sweetgrass, used for ceremonies, medicine, and tea, has never been reported in the study area.

Section 3.12.4 and Table 3-12.2 Cultural Resources, present additional discussion on the use and significance of local plants by Native Americans.

3.4.6 Metals Levels in Plant Tissues

Land application of waste water is the most likely scenario at the Zortman and Landusky mines where plants could uptake metals from soil or absorb metals through deposition on the foliage. Although no specific criteria are established for the land application of mining process solutions, the EPA has developed standards for the application of municipal wastewater and sewage sludge (EPA 1981, 1983). The criteria established are conservative and are intended to protect croplands against the accumulation of trace elements in soil and crops, and thus protect human health. Standards exist specifically for cadmium (Cd), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn), as these metals have been determined to pose the greatest environmental threat (Schafer and Associates 1993b).

Total metal accumulation by plants from soil or nutrient solutions depends on many factors including: (1) the nature of plants, such as species, growth rate, root size and depth, transpiration rate, and nutritional requirements; (2) soil factors such as pH, organic matter content and nature, nutrient status, and amount of metal ions and certain anions like phosphate, sulfate, and sulfides, and clay content and type; (3) environmental and management variables such as temperature, moisture, sunlight, and amendments and fertilization; and (4) the modes of metal toxicity and plant tolerance (Overcash and Pal 1979).

Pendias and Pendias (1992) also state that the fate of metals in soil and the potential uptake of the metals by plants is dependent on a number of environmental factors and the physical and chemical characteristics of the soil and the individual plant species. Numerous studies have shown a general relationship between concentrations of metals in soil and concentrations of metals in plants, and several researchers have developed proposals for maximum acceptable concentrations of trace elements in agricultural soil; however, there is not enough data to set up definite values for criteria needed to protect soil against the long-term effects of trace element pollution. Mullen (1994) and Lipton et al. (1993) in studies conducted on Superfund mining sites also show a strong relationship between metals in soil and metal concentrations in plants, noting that most contamination is found in the top two inches of soil.

Generally, effects of metal accumulation in plants are stunted growth of roots and tops, browning of leaves, interveinal chlorosis, wilting of the leaves, and red or brown spots on the leaves. However, each case of plant phytotoxicity is different, and, in fact, many plants may show no visible signs of injury. Therefore, it would be prudent to monitor soil in land application areas to ensure no impacts to soil and vegetation.

In September 1986, an above normal level of precipitation resulted in approximately 30 million gallons of excess solution inventory. The mine facility lacked the storage capacity necessary to accommodate further precipitation, and the regulatory agencies and ZMI determined treatment of the solution and an emergency land application was the best option. Approximately 20 million gallons of leachate was treated and disposed of over 17 acres. Haight et al. (1990) presented a paper on the environmental effects of the land application in which sampling of the application area soil and downgradient water quality showed impacts below those anticipated. Soil samples showed that metals in solution and residual cyanide were attenuated by the duff layer and uppermost soil horizons. The most noticeable effect to vegetation was some surficial "burning" of pine trees in the land application area due to excess chlorine in solution left from cyanide neutralization. (Note: chlorine is no longer being used in the neutralization process.) Understory vegetation showed little damage due to land application. After four years of monitoring, no negative effects to vegetation are attributed to the increased metal concentrations in the soil. All post-application metal levels are below levels considered toxic to plants and levels are expected to decrease over time.

In a report on "Selection and Evaluation of a Land Application Area for the Zortman Mine, Zortman, Montana" (Schafer and Associates 1993a), it was determined that it is unlikely that metals would concentrate in levels that pose a threat to vegetation, human health, or any state waters. These conclusions were based on the soil characteristics of the proposed land application area and the EPA standards for the land application of municipal wastewater (EPA 1981). In this study, the following land application process was modelled: 4.5 million gallons of solution was discharged onto 25 acres of land in Goslin Flats north and east of the proposed leach pad area at a rate of 75 gallons per minute, 8 to 12 hours a day from July to September. The study concluded that soil exhibits considerable variability in its adsorption tendencies and, although metal concentrations were typically low, no one soil offers the potential to attenuate all metals. The study went on to show that using normal irrigation practice criteria, the treated solution could be applied to soil without compromising metal adsorption capacity of the soil for 9-20 years. Considering the short duration of land application and the very low loading rates, it appears unlikely that soil or vegetation will be impacted by the proposed land application in Goslin Flats.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Ruby Gulch below the town of Zortman (including Ruby Tributary A)	Riverine Intermittent (D)	Low		Pre-1979
			Physical and Chemical Characteristics (L)	Channel modifications above the town of Zortman (tailings deposition) and diversion of Alder Gulch confluence may have severely decreased flow in Ruby Gulch. Lower Ruby Gulch's intermittent flow was likely sustained by springs. TDS, SO_4 levels were acceptable (Table 4.2-1); heavy metals were likely below detection limits.
			Biological Characteristics (L)	No known fishery; no data on other biological resources.
			Special Aquatic Sites (U)	Extent of wetlands unknown (wetland site #9 in Ruby Tributary A may have existed).
			Human Use Characteristics (L+)	Beneficial Uses: Provided limited range of uses. Surface water - Stockwater; no surface water rights. Groundwater - Springs used by livestock; domestic and stock groundwater rights.
		Low		1979-1990
			Physical and Chemical Characteristics (L-)	Minor flushes of sediment and poor surface water and groundwater quality (including decreased pH, cyanide detections, increased SC, TDS, SO_4, and metals) from mining activities.
			Biological Characteristics (L)	Similar to pre-1979.
			Special Aquatic Sites (L)	Wetland site #9 in Ruby Tributary A was well established and partially sustained by recently-installed stockwater well; other very small wetlands associated with seeps in lower Ruby Gulch occur outside of study area.
			Human Use Characteristics (L+)	Beneficial uses similar to pre-1979; however, possible surface water impacts due to negligible to minor perturbations associated with occasional high runoff carrying sediment and poor quality water.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Ruby Gulch below the town of Zortman (including Ruby Tributary A) (continued)	Riverine Intermittent (D) (continued)	Low		1990-1995
			Physical and Chemical Characteristics (L)	Construction of Ruby Gulch treatment system has significantly improved surface water quality; flushes of sediment from tailings deposit may still occur.
			Biological Characteristics (L)	Similar to pre-1979.
			Special Aquatic Sites (L)	Similar to 1979-1990.
			Human Use Characteristics (L+)	Similar to 1979-1990.
Ruby Gulch above the town of Zortman	Riverine Intermittent (D)	Low (Low end)		Pre-1979
			Physical and Chemical Characteristics (L-)	Channel modifications above the town of Zortman (tailings deposition) have severely disrupted flow in and the channel integrity of Ruby Gulch; limited sampling showed elevated TDS, SO_4 (Table 4.2-1); heavy metals were likely below detection limits.
			Biological Characteristics (L-)	No known fishery; no data on other biological resources. Aquatic habitat absent for much of this stream section.
			Special Aquatic Sites (U)	Extent of wetlands unknown.
			Human Use Characteristics (M-)	Beneficial Uses: provided moderate range of uses. Surface water - Stockwater; domestic and industrial (mining) surface water rights. Groundwater - Springs used by livestock; domestic, stockwater, and industrial (mining) groundwater rights.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Ruby Gulch above the town of Zortman (continued)	Riverine Intermittent (D) (continued)	Low (Low end/ Impaired)		1979-1990
			Physical and Chemical Characteristics (L-/Impaired)	Flushes of sediment and detectable ARD and cyanide from Zortman mining activities. Headwaters have been filled in by mining activities.
			Biological Characteristics (L-)	Similar to pre-1979.
			Special Aquatic Sites (U)	Similar to pre-1979.
			Human Use Characteristics (L-/Impaired)	Beneficial uses similar to pre-1979, however poor surface water quality led to development (1982) of a groundwater well to serve the town of Zortman; this well located in a side tributary and unaffected by mining, has shown no evidence of ARD.
		Low		1990-1995
			Physical and Chemical Characteristics (L)	Construction of Ruby Gulch treatment system has significantly improved surface water quality; flushes of sediment from unstabilized tailings deposit still occur.
			Biological Characteristics (L-)	Similar to pre-1979.
			Special Aquatic Sites (U)	Similar to pre-1979.
			Human Use Characteristics (L)	Uses similar to 1979-1990 but domestic water from wells; surface water quality has continued to improve with construction of the treatment system in the head of Ruby Gulch.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Alder Gulch below the town of Zortman	Riverine Intermittent (D)	Low (Low end)		Pre-1979
			Physical and Chemical Characteristics (L-)	Channel modifications/diversion from original confluence with Ruby Gulch near the town of Zortman have severely disrupted flow in and the channel integrity of lower Alder Gulch; sediment and water chemistry conditions unknown.
			Biological Characteristics (L-)	No known fishery; no data on other biological resources. Aquatic habitat absent for much of this stream section.
			Special Aquatic Sites (U)	Extent of wetlands unknown.
			Human Use Characteristics (L-)	Beneficial Uses: provided very limited range of uses. Surface water - No surface water rights. Groundwater - No springs; no groundwater rights.
				1979-1990
		Low (Low end)	Physical and Chemical Characteristics (L-)	Similar to pre-1979.
			Biological Characteristics (L-)	Similar to pre-1979.
			Special Aquatic Sites (L-)	No wetlands or other special aquatic sites identified.
			Human Use Characteristics (L-)	Similar to pre-1979.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Alder Gulch below the town of Zortman (continued)	Riverine Intermittent (D) (continued)	Low (Low end)		1990-1995
			Physical and Chemical Characteristics (L)	Similar to pre-1979.
			Biological Characteristics (L-)	Similar to pre-1979.
			Special Aquatic Sites (L-)	Similar to 1979-1990.
			Human Use Characteristics (L-)	Similar to pre-1979.
Alder Gulch above the town of Zortman (includes Alder Spur and Carter Gulch)	Riverine Upper Perennial (D) Riverine Intermittent (S)	Moderate (Low end)		Pre-1979
			Physical and Chemical Characteristics (L+)	Channel modifications have occurred in association with historic mining but channel integrity was generally reestablished; limited pre-1979 sampling in Alder Gulch indicates little ARD effects.
			Biological Characteristics (M)	No known fishery; no data on other biological resources. Aquatic habitat was likely present in most of Alder Gulch.
			Special Aquatic Sites (L)	Wetlands likely occurred where they are currently located; riffle-pool complexes of low quality likely occurred in Carter Gulch and upper Alder Gulch.
			Human Use Characteristics (M)	Beneficial Uses: provided moderate range of uses. Surface water - Numerous surface water rights (mining and domestic). Groundwater - Groundwater likely calcium bicarbonate type; springs/seeps common; groundwater rights (mining).

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Alder Gulch above the town of Zortman (includes Alder Spur and Carter Gulch) (continued)	Riverine Upper Perennial (D) Riverine Intermittent (S) (continued)	Low (Low end)/ Impaired		1979-1990
			Physical and Chemical Characteristics (L-/Impaired)	Headwaters of Alder Spur filled in from leach pads; sedimentation and some encroachment in Carter Gulch from Alder Gulch waste rock repository; deteriorating water quality (low pH, cyanide detection, elevated SO_4, SC, TDS) in Alder Spur and Carter Gulch; effects in lower Alder Gulch present but attenuated.
			Biological Characteristics (L)	Possible effects of degraded water quality on aquatic organisms unknown; however, overall macroinvertebrate numbers and taxa diversity was low and pollution-tolerant organisms were abundant indicating effects of natural perturbations and mining.
			Special Aquatic Sites (L)	Similar to pre-1979.
			Human Use Characteristics (M)	Similar to pre-1979.
				1990-1995
		Low (Low end/ Impaired)	Physical and Chemical Characteristics (L-/Impaired)	Period of decline in Alder Spur and Carter Gulch water quality; some improvement in water quality (sediments and chemistry) due to remedial actions taken in 1992.
			Biological Characteristics (L)	Similar to 1979-1990.
			Special Aquatic Sites (L)	Similar to 1979-1990; approximately 0.26 acres associated with the channel identified.
			Human Use Characteristics (L-/Impaired)	Groundwater exhibits calcium-sulfate chemistry indicative of mining impacts; alluvial and bedrock aquifers exhibit occasionally elevated SO_4, TDS, SC; numerous cyanide detections.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Goslin Flats	Riverine Intermittent (D)	Low		Pre-1979
			Physical and Chemical Characteristics (L)	Channel is well defined in the upper reaches and poorly defined in the lower reaches. Flows are ephemeral to intermittent. Three alluvial, spring fed stock ponds have been constructed. Outflow sustains small volume surface flow for short stretches, in channels that would otherwise receive only runoff. There is no pre-1979 water quality information. No mining activities have been located in the drainage, so it is assumed that water quality conditions are representative of natural conditions.
			Biological Characteristics (L)	No known fishery; no data on other biological resources. Aquatic habitat was not likely present except in the vicinity of the spring-fed stockponds. Waterfowl may use ponds for migration, possibly breeding. Wildlife water associated with stockponds (variety of species (poor cover) including Azure Cave bats).
			Special Aquatic Sites (L)	Wetlands likely occurred in association with springs and seeps and the channel.
			Human Use Characteristics (L)	Beneficial Uses: provided limited range of uses. Surface water - Surface water rights (livestock). Groundwater - Several perennial springs/seeps occur; groundwater rights (stockwater).
		Low		1979-1990
			Physical and Chemical Characteristics (L)	Sampling shows naturally high levels of TDS and SO_4, neutral pH; indicating on-going water/rock interactions with sediments and bedrock rich in minerals and SO_4.
			Biological Characteristics (L)	Similar to pre-1979.
			Special Aquatic Sites (L)	Similar to pre-1979.
			Human Use Characteristics (L)	Similar to pre-1979.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Goslin Flats (continued)	Riverine Intermittent (D) (continued)	Low		1990-1995
			Physical and Chemical Characteristics (L)	Similar to 1979-1990; visual surveys indicate some sediment inputs due to land use practices.
			Biological Characteristics (L)	Similar to 1979-1990.
			Special Aquatic Sites (L)	Similar to 1979-1990; approximately 1.8 acres of wetland identified (not including stockponds).
			Human Use Characteristics (L)	Similar to 1979-1990.
Lodgepole Creek	Riverine Intermittent (D) Riverine Upper Perennial (S)	Moderate		Pre-1979
			Physical and Chemical Characteristics (M+)	The watershed is a major drainage of the north slopes of the Little Rocky Mountains; channels are well defined. Flows are intermittent and fed by springs and headwater tributaries. No mining activities were located in the drainage.
			Biological Characteristics (M)	No known fishery within study area (brook trout known for lower reaches only); no data on other biological resources. Aquatic habitat was likely present.
			Special Aquatic Sites (M)	Narrow wetlands likely occurred in association with stream course and springs and seeps. Riffle-pool complexes of low to moderate quality also likely occurred.
			Human Use Characteristics (L+)	Beneficial Uses: provided limited range of uses. Surface water - Watershed provides water to the Fort Belknap Indian Reservation. Groundwater - Several perennial springs/seeps occur; no groundwater rights listed.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Lodgepole Creek (continued)	Riverine Intermittent (D) Riverine Upper Perennial (S) (continued)	Moderate (Low end)	Physical and Chemical Characteristics (M-)	1979-1990 Watershed capture has been altered by Ross and Ruby Pits and by activities in Glory Hole Creek and Lodgepole Tributary D; long-term effects unknown. Nitrates slightly elevated (1989-1993) presumably due to blasting or fertilizing; other water quality parameters indicate good water quality and no other impacts from mining.
			Biological Characteristics (M)	Similar to pre-1979.
			Special Aquatic Sites (M)	Similar to pre-1979.
			Human Use Characteristics (L+)	Similar to pre-1979.
		Moderate (Low end)	Physical and Chemical Characteristics (M-)	1990-1995 Similar to 1979-1990.
			Biological Characteristics (M)	Similar to 1979-1990; diverse macroinvertebrate populations documented.
			Special Aquatic Sites (M)	Similar to 1979-1990; well-established, about one acre of wetland identified.
			Human Use Characteristics (L+)	Similar to 1979-1990; groundwater quality shows no indication of impacts from mining.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Beaver Creek	Riverine Intermittent (D) Riverine Upper Perennial (S)	Moderate		Pre-1979
			Physical and Chemical Characteristics (M)	The watershed is a major drainage of the north and east slopes of the Little Rocky Mountains; channels are well defined. Flows are intermittent in the upper and fed by low-moderate volume springs; numerous beaver ponds (possibly spring-fed) occur in lower reaches above the Fort Belknap Indian Reservation boundary. Some historic mining occurred but channel restabilized.
			Biological Characteristics (M)	No known fishery within study area (brook trout known for lower reaches only); aquatic habitat was likely present; data on wildlife resources, good cover, high diversity, moderate productivity, active beavers.
			Special Aquatic Sites (M)	Narrow wetlands likely occurred in association with stream course, springs and seeps, and beaver activity. Riffle-pool complexes of low quality also likely occurred.
			Human Use Characteristics (M)	Beneficial Uses: provided limited range of uses. Surface water - Watershed provides water to the Fort Belknap Indian Reservation; surface water rights; irrigation - lower reach off study site and mining). Groundwater - Several perennial springs/seeps occur; no groundwater rights listed. High aesthetic values.
		Moderate		1979-1990
			Physical and Chemical Characteristics (M+)	No "modern" mining activities were located in the drainage; water quality parameters indicate good water quality and no impacts other from mining. Road use causes some sediment input.
			Biological Characteristics (M)	Similar to pre-1979.
			Special Aquatic Sites (M)	Similar to pre-1979.
			Human Use Characteristics (L+)	Similar to pre-1979 except mining uses stopped.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Beaver Creek (continued)	Riverine Intermittent (D) Riverine Upper Perennial (S) (continued)	Moderate		<u>1990-1995</u>
			Physical and Chemical Characteristics (M+)	Similar to 1979-1990.
			Biological Characteristics (M)	Similar to 1979-1990; about one acre of wetland identified.
			Special Aquatic Sites (M)	Similar to 1979-1990; well-established, diverse macroinvertebrate populations documented.
			Human Use Characteristics (L+)	Similar to 1979-1990; surface water shows no indication of impacts from recent mining; no groundwater quality data available.
Camp Creek	Riverine Intermittent (D) Riverine Upper Perennial (S)	Moderate (Low End)		<u>Pre-1979</u>
			Physical and Chemical Characteristics (M)	Small watershed area with well-defined channels.
			Biological Characteristics (M)	No known fishery within study area; no data on other biological resources; aquatic habitat was likely present; probably good habitat cover for other species.
			Special Aquatic Sites (L+)	Relatively extensive wetlands likely occurred in association with stream course, springs and seeps, and "sub-irrigated" areas.
			Human Use Characteristics (L+)	Beneficial Uses: provided limited range of uses. Surface water - Surface water rights (stockwater). Groundwater - Several perennial springs/seeps occur; groundwater rights (stockwater).

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES* FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
ZORTMAN				
Camp Creek (continued)	Riverine Intermittent (D) Riverine Upper Perennial (S) (continued)	Moderate (Low End)		1979-1990
			Physical and Chemical Characteristics (M)	No water quality data available.
			Biological Characteristics (M)	Similar to pre-1979.
			Special Aquatic Sites (L+)	Similar to pre-1979.
			Human Use Characteristics (L+)	Similar to pre-1979.
		Moderate (Low End)		1990-1995
			Physical and Chemical Characteristics (M-)	Similar to 1979-1990; no water quality data available; visual surveys indicate some drainage head-cutting and sediment inputs - likely due to land use practices.
			Biological Characteristics (M)	Similar to 1979-1990.
			Special Aquatic Sites (L+)	Similar to 1979-1990; about 7.5 acres of wetland identified.
			Human Use Characteristics (L+)	Similar to 1979-1990; no water quality data available.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity, or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
LANDUSKY				
Montana Gulch	Riverine Upper Perennial (D) Riverine Intermittent (S)	Moderate	Physical and Chemical Characteristics (M)	Pre-1979 Possible minor surface water quality impacts (elevated sulfates, TDS, SC, iron) resulting from Gold Bug Adit (GBA) discharge; perennial baseflow above confluence with Rock Creek attributed to GBA discharge; substrate varies from sand to bedrock.
			Biological Characteristics (M)	No known fishery; non-salmonid fishery exists downstream and off project site; no data on other biological resources.
			Special Aquatic Sites (M)	Intact narrow riparian wetlands associated with Montana Gulch; rated overall moderate (low end) for wetland functions and values; riffle-pool complexes occur in perennial reaches.
			Human Use Characteristics (M)	Beneficial uses: provides a moderate range of uses; both surface water and groundwater affected by pre-ZMI mining. Surface water - Agricultural diversions (water right). Groundwater - Domestic drinking water; agricultural diversion; mining; elevated arsenic at Montana Creek Campground well (never used).
		Low	Physical and Chemical Characteristics (L-/Impaired)	1979-1990 Similar to pre-1979 but with periodic increases in SO_4, TDS, SC, iron associated with ARD or capture pond spills; cyanide detections associated with the 83 and 86 leach pad pipeline ruptures; improvement has occurred since 1984 with treatment facilities; impacts primarily above confluence with Rock Creek; direct fill of channel by Montana Gulch waste rock dump and 85/86 leach pad; watershed alteration by these facilities plus Gold Bug waste rock dump and the 79 and 84 leach pads.
			Biological Characteristics (L-)	Sampled 1990; no visible periphyton; macroinvertebrate populations relatively low and possibly indicative of water quality effects; studies document general use of area by a variety of birds and mammals.
			Special Aquatic Sites (M-)	Similar to pre-1979 due to decreased water quality unknown.
			Human Use Characteristics (M-)	Similar to pre-1979 with additional surface water impacts from increased ARD and cyanide primarily in upper reaches; alluvial aquifers show occasional increases in SO_4, TDS, and SC; bedrock aquifers show cyanide; limestone aquifers provide neutralizing capacity.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA (Continued)

Drainage	Dominant (D)/ Subdominant (S) Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity, or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
LANDUSKY				
Montana Gulch (continued)	Riverine Upper Perennial (D) Riverine Intermittent (S) (continued)	Low (High end)	Physical and Chemical Characteristics (L-)	1990-1995 Similar to 1979-1990; water quality improvements have occurred but ARD and cyanide spills still occur.
			Biological Characteristics (L-)	
			Special Aquatic Sites (M-)	
			Human Use Characteristics (M-)	
Rock Creek/ Sullivan Creek	Riverine Intermittent (D)	Low	Physical and Chemical Characteristics (L+)	Pre-1979 Narrow, steep gradient with ephemeral to intermittent flows; substrate cobble-gravel some bedrock control; no indicated adverse impacts to water quality.
			Biological Characteristics (L)	No fishery; no data on benthic community or other biological sources.
			Special Aquatic Sites (L)	Limited wetland resources associated with upper Rock Creek and lower Sullivan Creek, rated low for functions and values.
			Human Use Characteristics (L)	Beneficial uses: Provides very limited range of uses. Surface water - No known water rights. Groundwater - Domestic drinking (lower portion of Rock Creek).
		Low	Physical and Chemical Characteristics (L)	1979-1990 Minor increases in TDS and SO_4 in downstream reaches of Rock Creek.
			Biological Characteristics (L)	Similar to pre-1979; Rock Creek sampled 1990 (macroinvertebrate populations relatively diverse with no indications of adverse impacts).
			Special Aquatic Sites (L)	Similar to pre-1979.
			Human Use Characteristics (L)	Beneficial uses similar to pre-1979; groundwater wells reflect minor negative impacts from mining.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity, or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
LANDUSKY				
Rock Creek/ Sullivan Creek (continued)	Riverine Intermittent (D) (continued)	Low (Low end)	Physical and Chemical Characteristics (L-)	1990-1995 ARD discharge to Sullivan Creek from 91 leach pad and elevated nitrates (probably due to fertilizer); minor water quality changes (increased TDS, SO_4) downstream, no changes to Rock Creek above Sullivan Creek; direct fill of Sullivan Gulch headwaters by 91 leach pad; impacts detected to the confluence with Mill Gulch.
			Biological Characteristics (L-)	Similar to pre-1979, but wildlife water may have been impaired.
			Special Aquatic Sites (L)	Similar to pre-1979.
			Human Use Characteristics (L)	Beneficial uses: Surface water - Groundwater - (water right) used for mining (dates not known); subtle trend shown in decreasing pH and increasing SO_4, TDS, and SC.
Rock Creek below Montana Gulch	Riverine Intermittent (D)	Moderate	Physical and Chemical Characteristics (M)	Pre-1979 Moderate gradient reach with developed floodplain but intermittent; water supply includes Gold Bug Adit discharge and springs on private property; substrate is gravel-cobble and cobble-rubble; no adverse water quality indicated.
			Biological Characteristics (M)	No fishery known; non-salmonid fishery occurs downstream in reservoirs; no benthic community data known; beaver activity may have been common; plant communities provide habitat diversity; grazing is historic use.
			Special Aquatic Sites (L+)	Intact, continuous riparian wetland associated with Rock Creek floodplain; rated low (high end) for functions and values.
			Human Use Characteristics (M)	Beneficial uses: Provides a broad range of uses. Surface water - Agricultural diversions (water rights); some recreational uses. Groundwater - Domestic drinking water; agricultural diversion.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity, or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
LANDUSKY				
Rock Creek below Montana Gulch (continued)	Riverine Intermittent (D) (continued)	Moderate		1979-1990
			Physical and Chemical Characteristics (M)	Slight increases in TDS, SO_4 levels; unknown sediment (other) inputs from adjacent land uses.
			Biological Characteristics (M)	Similar to pre-1979; beaver activity (ponds) may have increased; grazing impacts on vegetation communities unknown.
			Special Aquatic Sites (L+)	Similar to pre-1979; impacts from land use changes may have occurred but are not known.
			Human Use Characteristics (M)	Beneficial uses: Similar to pre-1979 with addition of mining. Surface waters - Slightly affected by adverse changes in water quality. Groundwater - Changes unknown.
		Moderate		1990-1995
			Physical and Chemical Characteristics (M)	Similar to 1979-1990.
			Biological Characteristics (M)	Similar to 1979-1990.
			Special Aquatic Sites (L+)	Similar to 1979-1990.
			Human Use Characteristics (M)	Similar to 1979-1990.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity, or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
LANDUSKY				
Swift Gulch/ South Bighorn Creek	Riverine Intermittent (D)	Moderate		Pre-1979
			Physical and Chemical Characteristics (M-)	Moderate to high gradient channel with a few perennial reaches; cobble-boulder and bedrock substrate; no water quality information. Areas at confluence of Swift Gulch and Big Horn Creek were disturbed by placer mining causing channel instability.
			Biological Characteristics (M)	No known fishery in Swift Gulch or Big Horn Creek; no data on other biological resources.
			Special Aquatic Sites (M)	Intact continuous wetlands associated with riparian floodplain rated overall moderate for functions and values.
			Human Use Characteristics (L+)	Beneficial Uses: Provides a limited range of uses. Surface water - Watershed supplies a portion of water for Fort Belknap Indian Reservation. No other surface water rights. Groundwater - No groundwater water rights.
		Moderate (Low end)		1979-1990
			Physical and Chemical Characteristics (L+)	Rising concentration of sulfates, SC, and nitrates since monitoring started in 1985; indicates drainage from Landusky Mine site may have affected water quality (no groundwater monitoring in Swift Gulch); overall hydrologic/watershed function may have been affected by Queen Rose and Little Ben pits; channel has stabilized somewhat.
			Biological Characteristics (M)	Macroinvertebrate sampling indicates good water quality; wildlife studies document general use of area by a variety of birds and mammals.
			Special Aquatic Sites (M+)	Similar to pre-1979; where disturbed areas have stabilized somewhat after the creek reestablished, small wetlands areas are emerging.
			Human Use Characteristics (L)	Similar to 1979-1990; changes in viewscape due to variety of land use changes.
		Moderate (Low end)		1990-1995
			Physical and Chemical Characteristics (L+)	Same as 1979-1990.
			Biological Characteristics (M)	Same as 1979-1990.
			Special Aquatic Sites (M+)	Same as 1979-1990.
			Human Use Characteristics (L)	Same as 1979-1990.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity, or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
LANDUSKY				
Mill Gulch	Riverine Intermittent (D)	Low		Pre 1979
			Physical and Chemical Characteristics (L)	Primarily narrow steep ephemeral drainage with intermittent midsection supplied by a spring; substrate is gravel-cobble with some bedrock control; no indicated adverse impacts to water quality.
			Biological Characteristics (L)	No fishery; no data on benthic community or other biological resources.
			Special Aquatic Sites (L)	Very limited wetland resources associated with Mill Gulch intermittent/spring flows; rated low for function and values.
			Human Use Characteristics (L)	Beneficial uses: Provides limited range of uses. Surface water - No water rights known. Groundwater - Groundwater rights; mining.
		Low (Low end/ Impaired)		1979-1990
			Physical and Chemical Characteristics (L-/Impaired)	Cyanide detections and ARD (increases in TDS, SC, and lowered pH) evident from construction and several spills at 87 Mill Gulch leach pad and 83 leach pad; direct fill of upper Mill Gulch due to 87 leach pad and Mill Gulch waste rock dump.
			Biological Characteristics (L)	Lower Mill Gulch sampled in 1990; no periphyton observed; macroinvertebrate populations relatively diverse.
			Special Aquatic Sites (U)	Unknown whether water quality changes affected wetlands.
			Human Use Characteristics (L-)	Groundwater quality degraded by cyanide and occasional increases in SO_4, TDS and SC. Surface water affected as noted above; impacts to beneficial uses unknown.
		Low (Low end)		1990-1995
			Physical and Chemical Characteristics (L-)	Water quality impacts continue but have been improved due to treatment/capture systems.
			Biological Characteristics (L)	Similar to 1979-1990.
			Special Aquatic Sites (U)	Similar to 1979-1990.
			Human Use Characteristics (L)	Bedrock groundwater has shown improvement (attenuated by limestone aquifer).

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA
(Continued)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity, or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
LANDUSKY				
King Creek	Riverine Upper Perennial (D) Riverine Intermittent (S)	Moderate		Pre-1979
			Physical and Chemical Characteristics (L+)	Narrow high gradient intermittent stream within project area becoming moderate to low gradient and perennial off site; historic adit on headwaters and tailings deposition in channel; slightly elevated SO_4 due to these sources.
			Biological Characteristics (M)	No fishery known; no specific site data on other biological resources available; assume usage by a wide variety of birds and mammals including beaver.
			Special Aquatic Sites (M)	Very narrow wetlands associated with upper King Creek and joining intermittent tributaries; rated moderate (high end); contiguous with more extensive riparian floodplain wetlands downstream (off site).
			Human Use Characteristics (M)	Beneficial uses: Provide limited uses within project area; impaired by water quality conditions to an unknown degree. Surface Water - Recreational use (limited on site), cultural (tribal) needs. Groundwater - None known.
		Moderate (Low End)		1979-1990
			Physical and Chemical Characteristics (L-)	Increases in sulfates, TDS, SC indicate ARD impacts; total suspended sediments also evident due to erosion of tailing; changes in surface water and groundwater hydrology resulting from pits (especially) Gold Bug may have decreased flow potential.
			Biological Characteristics (M)	Numerous wildlife studies in the project document general use of area by number of birds and mammals; beaver activity on-going.
			Special Aquatic Sites (M)	Assume similar to pre-1979; possible changes due to watershed alteration and hydrologic supply may have affected wetlands; however, no data exists to evaluate changes.
			Human Use Characteristics (M-)	Beneficial uses similar to pre-1979; nitrates (from blasting) and SO_4, TDS, and SC elevated in surface water and groundwater; studies identify no human health risks.

TABLE 3.4-3
SUMMARY OF EXISTING NON-WETLAND FUNCTIONS AND VALUES FOR ZORTMAN-LANDUSKY PROJECT AREA
(Concluded)

Drainage	Dominant (D)/ Subdominant (S) Non-Wetland Waters of the U.S. System	Overall Function/Value Rating	Functions and Values Provided at Low (L), Moderate (M), High (H), or Unknown (U) Level for Effectiveness, Opportunity, or Social Significance*	Rationale: Attributes listed or comment given briefly explains why the function or value was rated accordingly.
LANDUSKY				
King Creek (continued)	Riverine Upper Perennial (D) Riverine Intermittent (S) (continued)	Moderate	Physical and Chemical Characteristics (M)	1990-1995 Similar to 1979-1990; except ZMI has removed tailing and stabilized channel which has significantly reduced suspended sediment loads in King Creek; overall hydrologic changes to watershed are on-going.
			Biological Characteristics (M)	Similar to 1979-1990.
			Special Aquatic Sites (M)	Similar to 1979-1990.
			Human Use Characteristics (M)	Similar to 1979-1990. (Future changes due to tailing removal and channel stabilization, unknown).

***NOTES:**

Physical and Chemical Characteristics of the Aquatic Ecosystem:
Characteristics evaluated included substrate; water; current patterns and water circulation; normal water fluctuations; and salinity gradients.

Biological Characteristics of the Aquatic Ecosystem:
Characteristics evaluated included threatened and endangered species; fish, crustaceans, mollusks, and other aquatic organisms in the food web; other wildlife associated with aquatic ecosystems (both resident and transient).

Special Aquatic Sites of the Aquatic Ecosystem:
These are geographic areas, large or small, possessing special ecological characteristics of productivity, habitat, wildlife protection, or other important and easily disrupted ecological values. These areas are generally recognized as significantly influencing or positively contributing to the general and overall environmental health or vitality of the entire ecosystem of a region. Special aquatic sites include sanctuaries and refuges; mudflats; vegetated shallows; coral reefs; wetlands; and pool-riffle complexes. The latter two were identified at the Zortman-Landusky study area. See discussions in Section 3.4.

Human Use Characteristics:
Characteristics evaluated included municipal and private water supplies (both surface water and groundwater); recreational and commercial fisheries; water-related recreation; aesthetics (combination of the senses that contribute to the quality of life of all); parks and other preserves that have been designated under federal, state, or local actions that are managed for aesthetic, educational, historical, recreational, or scientific value.

Modified from 40 CFR Part 230 - Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material; Subparts C, D, E, and F.

Source: Analysis by OEA Research, Inc., Helena, MT, January 1996; revised March 1996.

3.5 WILDLIFE AND AQUATICS

3.5.1 Wildlife

Numerous wildlife species have traditionally used the Little Rocky Mountains for all or part of their existence. Wildlife habitats in and around the Little Rocky Mountains have been greatly changed by settlement, irrigation, cultivation, and mineral extraction. Nineteen species of mammals have been documented in the Little Rocky Mountains, including mule and white-tailed deer, elk, bighorn sheep, elk, coyote, badger and numerous small mammals (DSL 1979a). Some animals (white-tailed deer, raccoon, fox) have likely become more numerous with recent changes in wildlife habitats.

A diversity of wildlife habitats occurs in the Little Rocky Mountains and adjacent prairies. High elevation peaks have scree slopes and wind-blown ridges, providing feeding and wintering areas for marmots and bighorn sheep. Deeply eroded steep canyons offer cliffs for raptor nesting and escape cover for bighorn sheep, elk, and mule deer. Numerous caves provide habitat for bats and woodrats. Lodgepole pine stands provide nesting requirements for numerous birds such as American robin, black-capped chickadee, downy woodpecker, yellow-rumped warbler, and ruby-crowned kinglet; and provide escape cover for deer and elk (Westech 1991). Large forest fires have created a mosaic of dense forest interspersed with open meadows, providing preferred feeding areas for big game and woodpeckers. Low elevation, south-facing slopes support a diversity of shrub species, providing browse and snow-free areas for wintering wildlife. Lower elevation riparian zones support aspen and willow communities, providing habitat requirements for turkeys, passerine birds and small mammals. Adjoining shortgrass prairies provide habitat for pronghorn antelope and foraging areas for raptors.

Numerous wildlife studies have been conducted within the Zortman mining area, including a general reconnaissance of the area (Farmer 1977) and a series of baseline and supplemental studies (Scow 1978, 1979, 1983; Westech 1985, 1986, 1989). An environmental analysis of the impacts of the proposed Zortman mine was conducted in 1978 (Westech 1978). A supplemental study conducted in 1990 summarized the above reports into one document (Westech 1991). Reports on the wildlife found in Azure Cave have been prepared by Chester et al. (1979), and Butts (1993). The BLM has summarized region-wide wildlife data in the Judith Valley Phillips Resource Management Plan EIS (BLM 1992b). A listing of all study area wildlife species, including common and scientific names for species recorded in the wildlife studies, is available in the Zortman permit application, Appendix 5 (ZMI 1993).

The responsibility for managing Montana wildlife rests with the MDFWP; local MDFWP staff were consulted to verify and supplement available data. Wildlife habitat within the project area is managed by the BLM. Wildlife residing within the borders of the Fort Belknap Indian Reservation are managed by a wildlife biologist recently hired by the tribal government. The USFWS is mandated to provide assistance to the tribe concerning reservation wildlife management plans and strategies. Wildlife protected under the Endangered Species Act (ESA) and Migratory Bird Treaty Act are managed by land management agencies (specifically the BLM within the Little Rocky Mountains) in consultation with the USFWS.

3.5.1.1 Special Status Species

Special status species include species listed as threatened and endangered (T/E) by the USFWS, those under review (Category 1 and 2) for endangered and threatened status, and species of special interest or concern listed by MDFWP (Flath 1995). A listing of federal threatened and endangered species which could occur in the project area was provided by the USFWS (1995).

A review of available data revealed 18 wildlife species of special concern which may potentially occur in the project area (Table 3.5-1). Four of these species (bald eagle, peregrine falcon, piping plover, and black-footed ferret) are listed as endangered. One species (mountain plover) is a Category 1 candidate species, with sufficient data available for listing. Ten other species (ferruginous hawk, northern goshawk, burrowing owl, loggerhead shrike, Baird's sparrow, Townsend's big-eared bat, northern long-eared myotis, fringed myotis, long-legged myotis, and western small footed myotis) are considered Category 2 candidate species, which may be suitable for listing, but sufficient data are lacking on a national level to do so at this time. Additional species of special concern, listed by MDFWP, include black-tailed prairie dog, sharp-tailed grouse, and long-billed curlew.

Threatened and Endangered Species

An endangered species is one that faces extinction throughout all or a significant portion of its range. Threatened species are those likely to become endangered in the future.

TABLE 3.5-1
WILDLIFE SPECIES OF CONCERN POTENTIALLY OCCURRING ON OR NEAR THE PROJECT SITE

Common Name	Scientific Name	Federal Status*	State Status*
Peregrine Falcon	*Falco peregrinus*	E	E
Bald Eagle	*Haliaeetus leucocephalus*	E	S
Piping Plover	*Charadrius melodus*	E	S
Black-footed Ferret	*Mustela nigripes*	E	S
Ferruginous Hawk	*Buteo regalis*	C-2	S
Mountain Plover	*Charadrius montanus*	C-1	S
Long-billed Curlew	*Numenius Americanus*	--	S
Black-tailed Prairie Dog	*Cynomys ludovicianus*	--	S
Northern Goshawk	*Accipiter gentilis*	C-2	S
Sharp-tailed Grouse	*Tympanuchus phasianellus*	--	UB
Burrowing Owl	*Athene cunicularia*	C-2	S
Loggerhead Shrike	*Lanius ludovicianus*	C-2	S
Baird's Sparrow	*Ammodramus bairdii*	C-2	--
Townsend's Big-eared Bat	*Corynorhinus townsendii*	C-2	S
Northern Long-eared Myotis	*Myotis evotis*	C-2	S
Fringed Myotis	*Myotis thysanades*	C-2	S
Long-legged Myotis	*Myotis volans*	C-2	--
Western Small Footed Myotis	*Myotis ciliolabrum*	C-2	--

*Definitions:

E = Federally listed as endangered
S = State listed as Species of Special Interest or Concern
UB = Upland Game Bird
C-1 = Federally listed as Category 1 - current information indicates that species qualify for protection under the Endangered Species Act.
C-2 = Federally listed as Category 2 - current information indicates that species might qualify for protection under the Endangered Species Act, but further biological information is needed.

Sources: USFWS 1992, 1993
MDFWP 1992

Four species of wildlife that are federally classified as endangered do potentially occur in South Phillips County; however, no endangered species occur within the proposed mine area. No species listed as threatened potentially occur in the project area. Brief descriptions of endangered species and their habitat are provided below.

Bald Eagle - The bald eagle is a federally listed endangered species. Montana state law does not list the bald eagle as either endangered or threatened, but as a "Species of Special Interest or Concern" (Flath 1984); however, federal law supersedes state law. Bald eagles are very rare in the Little Rocky Mountains and have not been observed on the project site. Bald eagles have been recorded in the Little Rocky Mountains on one occasion during Audubon Society Christmas Bird counts (American Birds 1982). However, bald eagles are winter residents within Phillips County, particularly along the Missouri and Milk Rivers, concentrating in areas of open water where fish and waterfowl are available as food sources (BLM 1992b).

There are no known bald eagle nests or essential habitat in the Little Rocky Mountains, and open water bodies that could provide nesting or foraging habitat do not exist (Westech 1991). The Phillips Resource Area is used during spring and fall migration, with peak use occurring in March, April, and November. Bald eagles appear to migrate through Phillips County somewhat concurrent with the waterfowl spring and fall migrations (BLM 1992b).

Peregrine Falcon - The peregrine falcon is a federally and state listed endangered species. Peregrine falcons generally nest on high steep cliffs that provide commanding views, in open country or mountain parkland. They usually occupy the same territory and often the same ledge or eyrie from year to year (Ratcliffe 1980). Peregrine falcons have been sighted during migration seasons in southern Phillips County (BLM 1985). DeLap (1962) reported breeding peregrine falcons in the Little Rocky Mountains in 1961, but did not report the location of the nest.

Potentially suitable habitat exists in the Little Rocky Mountains. Two separate studies conducted during the late 1970s thoroughly searched the non-reservation portion of the mountains during the nesting season, and no peregrines were observed (Farmer 1977, Scow 1978). Seven peregrine falcon sightings were recorded during spring of 1986 within the Phillips Resource Area (BLM 1986). An area of the Little Rocky Mountains containing potential cliff nesting sites for peregrines was searched in July 1985 and April 1986. Prairie falcons were actively defending territories at this site, prohibiting the establishment of a peregrine falcon nesting territory (BLM 1985, 1986). Currently, a peregrine falcon working group is investigating sites within the Phillips Resource Area, including the Little Rocky Mountains, for potential reintroduction of peregrine falcons. Additionally, potential nesting sites within 1/2 mile of the proposed mine development were searched in 1990 and no evidence of peregrine falcons was found (Westech 1991).

Black-footed Ferret - The black-footed ferret is federally listed as an endangered species and listed by the State of Montana as a Species of Special Interest or Concern. Black-footed ferrets depend on prairie dog colonies as a source of food and shelter (BLM 1984). Changes in land-use practices and poisoning programs over the last century have substantially reduced prairie dog distribution in the western United States. As a result, all active prairie dog towns (or a complex of towns) large enough to support ferrets are considered potential black-footed ferret habitat. Current USFWS criteria for defining potential black-footed ferret habitat specifies that any black-tailed prairie dog town or complex larger than 80 acres, and any white-tailed prairie dog colony or complex larger than 200 acres, should be considered (USFWS 1989).

There are historical records of black-footed ferrets in the prairie habitat within Phillips Resource Area, but none within the Little Rocky Mountains. Flath and Clark (1986) list two ferret specimens from Phillips County in 1923 and 1924. Recent unconfirmed sightings have been made in adjoining areas, and skeletal remains were found on the Fort Belknap Indian Reservation in 1983.

The historic range of the ferrets corresponds to the range of black-tailed prairie dogs. The black-footed ferret recovery plan suggests that at least one population of ferrets should be reintroduced into states that make up its historic range, which includes Montana. A group of biologists known as the Montana Black-Footed Ferret Working Group, studying prairie dogs since 1984, has selected four top sites for potential reintroduction within Montana. All four sites are within or associated with the Phillips Resource Area. Further evaluation selected a prairie dog complex (7km Complex) within the Phillips Resource Area. Ferrets were reintroduced into the area in 1994. There are no prairie dog towns or black-footed ferret habitat in or adjacent to the project area.

The BLM has designated prairie dog towns on BLM land within the 7km Complex as an Area of Critical Environmental Concern (ACEC), to be managed for

black-footed ferret reintroduction (BLM 1992b). This ACEC is located south and east of the proposed project, approximately 8 miles from the southern boundary.

Piping Plover - The piping plover is a federally listed endangered species and a Montana Species of Special Interest or Concern. Nesting piping plovers have been documented on the Bowdoin National Wildlife Refuge and Nelson Reservoir, approximately 50 miles northeast of the proposed project. This species is known to migrate from Saskatchewan during early August. Throughout its range, the piping plover nests on wide beaches with minimal vegetative cover (Gaines and Ryan 1988). Piping plovers in Montana nest on sand/pebble beaches of large permanent reservoirs and natural lakes. Plovers in North Dakota use saline wetlands. Both of these habitats do not occur within or near the project area. Surveys conducted by Montana Fish Wildlife and Parks (Flath Pers. Comm. w/R. Beane) and element occurrence searches conducted by the Montana Natural Heritage Program (1992) reveal that the nearest breeding piping plover occur at Fort Bowdoin National Wildlife Refuge, more than 50 miles away. Other occurrences at Nelson Reservoirs and Fort Peck are more than 65 and 100 mile east, respectively. Additionally, site-specific wildlife studies found no piping plovers on the project site (Westech 1991).

Federal Candidate Species

The project area supports or contains potential habitat for eleven federal candidate species (ferruginous hawk, mountain plover, northern goshawk, burrowing owl, loggerhead shrike, Baird's sparrow, small footed myotis, northern long-eared myotis, fringed myotis, long-legged myotis, and Townsend's big-eared bat (CFR 59 (219):58952-59028). The mountain plover is a Category 1 species, and enough data are available to consider the species for listing (May 3, 1993). The remaining species are Category 2 species, which means current information indicates that species might qualify for protection under the Endangered Species Act, but further biological information is needed.

Mountain Plover - The mountain plover is found on the open shortgrass (blue grama/clubmoss) prairies (Finch 1992). They migrate into the area in late April and are gone by early September (BLM 1992b). The plover nests on open ground and relies on insects and seeds for food. No mountain plover have been observed in the project area. Most of the known plovers in the area surrounding the project site are associated with level shortgrass prairie and often occur in black-tailed prairie dog towns.

Burrowing Owl - The burrowing owl is a small owl of open plains and prairies. Primarily diurnal, this owl uses abandoned mammal burrows for nesting and raising young. The owl is often associated with prairie dog towns, but also uses ground squirrel burrows that have been enlarged by badgers. No burrowing owls have been observed on the project area (Westech 1991), and the closest prairie dog town occurs 7 to 10 miles south of the Little Rocky Mountains.

Ferruginous Hawk - The ferruginous hawk is the largest and most powerful of North American buteos, and is endemic to prairie and grassland habitats in Western North America (Brown and Amadon 1968). They were historically found in most states west of the Mississippi River, but populations have declined as cultivation has converted grassland into cropland (Olendorff 1973). Ferruginous hawks typically nest on the ground or on small outcrops in prairie habitats. Small and medium sized mammals are the primary prey species of ferruginous hawks, including cottontail rabbits, jackrabbits, prairie dogs and ground squirrels. Ferruginous hawks migrate into the project area in late March and leave in late October (BLM 1992b). A study of ferruginous hawk reproduction in Phillips County (Black 1992) revealed ferruginous hawks scattered widely across the county, occupying areas of open ground with moderate relief. Thirty-eight nests were located. Seventy-six percent of these nests were found on the ground, and all nests were found in areas with some topographic relief (Black 1992). Ferruginous hawks have been observed within the study area (Westech 1991); however, no nest sites occur within 10 miles of the project area (Black 1992).

Northern Goshawk - The northern goshawk is the largest North American member of the genus *Accipiter* and inhabits coniferous, deciduous, or mixed forests. This species requires large coniferous or deciduous trees in older stands for nesting. Nesting stands typically have a high degree of canopy closure and are often located on northern aspects (Reynolds 1989). Suitable nesting habitat is critical to the reproductive biology of goshawks. Nest areas are frequently reused for years and many goshawks have between two and four alternate nest areas within their home range. Nest areas are occupied by breeding goshawks from early March until late September (Reynolds et al. 1992). Goshawks prey on small to mid-sized birds and mammals, which they capture on the ground, in trees, or in the air (Reynolds et al. 1992). In Montana, the goshawk occurs primarily in coniferous forests and is common in many areas, but definitive data is lacking (Flath 1995). The Montana Natural Heritage Program has no recorded occurrences of goshawks in the Little Rocky Mountains

(Hinshaw 1994); however, an adult goshawk (probably a migrant) was observed in Mill Gulch in October 1985 (Farmer 1994) and the BLM has a single record of a nest in the Little Rocky Mountains approximately 1.5 miles north of the project site (Grensten 1994).

Loggerhead Shrike - The loggerhead shrike is a perching bird of pasture, savannah and open brushland and is territorial in winter as well as summer (Fraser and Luukkonen 1986). Shrike nest earlier than most other passerines, laying eggs as early as April and May. Shrikes typically nest in open country in a variety of trees, shrubs, or vines and require trees or shrubs for nesting, roosting and hunting (Fraser and Luukkonen 1986). Loggerhead shrike occur primarily in the eastern part of Montana and have been observed on the project area (Westech 1991).

Baird's Sparrow - The baird's sparrow breeds from southeastern Alberta to southern Manitoba south to central and eastern Montana to central North Dakota. It winters from southeastern Arizona to north-central Texas into Mexico. This species favors large areas of prairie grassland with patchy shrubs. It also inhabits areas of ungrazed or lightly grazed mixed grass prairies, moist meadows, tall-grass prairies associated with wetlands, dry rangelands, fallow and stubble fields and hayfields. This species is sensitive to disturbance and requires relatively undisturbed or reclaimed prairie grasslands with scattered shrubs for breeding. Baird's sparrows nest on the ground in tall dense grass or dense herbaceous vegetation (Degraaf et al. 1991). There is no habitat or record of the Baird's sparrow in the Little Rocky Mountains.

Townsend's Big-eared Bat - The Townsend's big-eared bat ranges throughout western North America from southern British Columbia to southern Mexico, inhabiting a variety of habitats including desert scrub, pinyon-juniper and pine forests (Barbour and Davis 1969). This bat is usually solitary or occurs in small groups and can be found in mines, caves, and man-made structures occurring at elevations up to 9,500 feet. The Townsend's big-eared bat is relatively sedentary and does not make major migrations. Winter hibernation areas (hibernacula) are selected that supply stable low temperatures and possibly a moderate airflow. This bat is sensitive to changes in temperature and humidity while hibernating (Freeman 1984). Townsend's big-eared bat has been recorded at Azure Cave.

Fringed Myotis - The fringed myotis is a species of western North America, ranging from British Columbia south to Veracruz and Chiapas, Mexico. This myotis is a species of wooded areas in foothills, mountains and high plateaus at elevations from 4,000 to 11,000 feet (Armstrong 1984a, Barbour and Davis 1969). Typical habitat is montane or subalpine forest, with oak and pinyon woodlands apparently the most commonly used habitat (Armstrong 1984a, O'Farrel and Studier 1980). Fringed myotis roost singly or in small groups. This species is known to migrate short distances to hibernate in mines or caves. The fringed myotis is easily disturbed by human activity, particularly during breeding (O'Farrel and Studier 1980). This bat has not been recorded on or near the project site.

Northern Long-eared Myotis - The northern long-eared myotis ranges widely in western North America from central Mexico to British Columbia. This is a species of high mountain coniferous forests, where they roost in trees, buildings, caves and abandoned mines (Armstrong 1984b). The long-eared myotis emerges after dark to forage near trees or over water. This species is a gleaner, taking insect prey from the surface of leaves (Armstrong 1984b). Long-eared myotis have been recorded to occur at Azure Cave.

Western Small-footed Myotis - The western small-footed bat occurs throughout western North America. Little is known about this species' habitat, although it is known to inhabit rocky areas. This species is generally solitary and roosts in summer in buildings, mines and under tree bark. In winter the small footed myotis is found in caves and mines, either alone or in small groups. One small-footed myotis has been recorded at Azure Cave.

Long-legged Myotis - The long-legged myotis is a species of western North America from central Mexico to extreme northwestern British Columbia and from the Pacific coast to the western edge of the Great Plains. This species occurs in wooded areas of foothills and mountains. Typical habitat is montane or subalpine forest, pine woodland and montane shrub. This bat roosts by day singly or in small groups in buildings, fissures of rocks and beneath loose bark. The long-legged myotis hibernates singly or in small groups in cave or mines (Armstrong 1984c). The long-legged myotis has been recorded at Azure Cave.

State Species of Special Interest or Concern

Black-tailed Prairie Dog - The prairie dog occupies relatively level ground in short and mid-prairie habitats. Prairie dogs were originally recorded by Lewis and Clark in Phillips County in 1805 and were considered very much a part of the prairie ecosystem by Phillips County Extension Agents in 1917. Poisoning of prairie dog colonies began in 1931, and strychnine oats were spread over 170,000 acres of Phillips County between 1931 and 1933. Poisoning continued until 1939, when it was felt that prairie dogs had been eliminated from Phillips County. Prairie dogs began to expand in the 1950s, and in 1982 the BLM prepared the Programmatic Environment Assessment for Black-tailed Prairie Dog Control/Management in the Phillips Resource Area. In 1983, the BLM began a shooting program to manage and limit prairie dog expansion within Phillips Resource Area. No prairie dogs occur within the study area, and the closest prairie dog towns are 7 to 10 miles south of the project area.

Sharp-tailed Grouse - Sharp-tailed grouse is a state game species that occurs in intermountain grasslands, and on prairie bottoms and draws south of the Little Rocky Mountains. Important habitats for the sharp-tailed grouse include grassland, grassland shrub, riparian, woodland and agricultural areas (BLM 1992b). During winter, woody draws and woodlands are used for thermal cover. If snow is not available for burrowing into during severe winter weather, grouse would move to shrubby vegetation for thermal cover (BLM 1992b). Grouse have been observed in the project area in the lower creek drainages, and historical "leks" are present in or near the southeastern boundary of the project area (Westech 1991, Grensten 1994).

Long-billed Curlew - The long-billed curlew typically nests in remnants of original prairie habitat, including damp meadowland and drier short-grass areas, particularly on gravelly soil (Hayman et al. 1986). Breeding curlews typically feed on grassland insects and seeds. After breeding, curlews move to estuaries and some winter on inland cultivated areas. Long-billed curlews are found in prairie habitats in South Phillips County. They migrate into the area in late March and leave in late September (BLM 1992b). No long-billed curlews have been observed on the project area (Westech 1991).

3.5.1.2 Important Wildlife Species

Important classes of wildlife which generated substantial EIS public scoping comments include big game animals, upland game birds, raptors and bats. Numerous other wildlife species are present and have been documented in the project area.

Big Game Animals

Big game species that may occur on the permit area include, bighorn sheep, mule deer, white-tailed deer, elk, pronghorn, black bear, and mountain lion. Abundance and distribution of big game in the Little Rocky Mountains are limited to a large extent by hunting mortality. Game animals that use lands within the Fort Belknap Indian Reservation are hunted year round. Road development within the southern portion of the mountains make animals easily accessible during Montana hunting seasons. Only the bighorn sheep and mule deer are capable of supporting substantial populations under these conditions. Elk, mountain lion, white-tailed deer, and black bear populations are depressed below habitat carrying capacities due to both legal and illegal hunting mortality (BLM 1992a).

Bighorn Sheep - Forty-one bighorn sheep were introduced into the Little Rocky Mountains between 1972 and 1974 (Scow 1978). This herd has remained fairly stable and currently consists of approximately 60 animals, primarily located in the southern portion of the Little Rocky Mountains (Westech 1991). The herd appears to have reached the carrying capacity of its current range. The herd does not appear to have distinct summer and winter ranges, and thus is not considered migratory (Westech 1991). A majority of animals winters along the southern fringes of the mountain range and disperses to higher elevations north in the summer. Several bighorn sheep (including some of the larger rams) may also summer on the Fort Belknap Indian Reservation. Bighorn sheep population size, composition and winter population characteristics is provided in the "Wildlife Resources of the Little Rocky Mountains Environmental Study Area" (Westech 1991).

Mule Deer - Mule deer are the most common big game animal in the Little Rocky Mountains. They range throughout the mountains from spring through fall. However, mule deer are generally confined to the southern exposures of the mountains at lower elevations in the winter (Westech 1991).

White-tailed Deer - White-tailed deer have been recorded throughout the Little Rocky Mountains, and the BLM (1972) reported that the mountain range has high value white-tailed deer habitat along major creek bottoms, including Camp Creek, Alder Gulch, Lodgepole Creek and Beaver Creek. White-tailed deer habitat typically involves low elevation riparian zones, where dense vegetation provides escape cover from

predators and hunting pressure. Disturbance to this habitat in the southern portion of the range and an open hunting season to the north has prevented the expansion of this species.

Elk - Elk were traditional inhabitants of the Little Rocky Mountains. Elk were reintroduced into the nearby Missouri River Breaks in 1951 and flourished; elk were occasionally sighted in the Little Rocky Mountains in Grouse Gulch, Alder Gulch, Ruby Gulch, and C-K Creek (Scow 1978). In 1972, the BLM concluded that the Little Rocky Mountains contain some moderate to high-value elk habitat, but the overall value is limited by the small size of the mountain range. Overharvest and disturbance to their native habitat has severely limited elk abundance and distribution in this mountain range. Current elk use of the Little Rocky Mountains appears to involve dispersal from the more secluded Missouri River Breaks. MDFWP objectives call for management of elk habitat in its most productive condition and provision of maximum recreation opportunity. Specific management objectives for the Missouri River Breaks Elk Management Unit include maintaining the population at current levels, maintaining current annual harvest, and developing cooperative programs that encourage public and private land managers to maintain productive elk habitat (MDFWP 1992).

Pronghorn - Pronghorn antelope use of the Little Rocky Mountains is confined to the sagebrush/grassland foothills. Some animals may occasionally use areas near Goslin Flats.

Black Bear - Studies conducted in the 1970s found no evidence of black bears in the Little Rocky Mountains (Scow 1978, 1979). However, in recent years black bears have been harvested and reported in very limited numbers in the Little Rocky Mountains. Dispersal from the Missouri River Breaks probably accounts for these observations.

Mountain Lion - Mountain lion occur in the Little Rocky Mountains in very limited numbers. MDFWP estimated the 1985-1986 population at 3 to 6 lions (Harvey Nyberg, MDFWP, in Westech 1991). Most of the lions in the Little Rocky Mountains are probably yearlings that have migrated from the Missouri River Breaks, but there are reports that at least one lion litter was produced in the area in 1986 (Harvey Nyberg, MDFWP, in Westech 1991). Observation of what appeared to be a mountain lion deer kill, indicated by a deer carcass and lion tracks, was recorded in the Azure Cave area by an EIS team biologist in winter of 1993.

Upland Game Birds

Six species of upland game birds (ring-necked pheasant, grey partridge, sharp-tailed grouse, blue grouse, wild turkey, and sage grouse) may occur near the proposed project area. Pheasant, grey partridge, and sharp-tailed and sage grouse inhabit the foothills surrounding the Zortman operation. Blue grouse use of the permit area occurs regularly. Wild turkeys were released in the Little Rocky Mountains in the early 1970s. The birds never appeared to multiply, possibly due to drought conditions, poor winter range, and overharvest. Some wild turkeys may remain in the Little Rocky Mountains and on adjacent private land.

Raptors

Numerous birds of prey (or raptors) use the Little Rocky Mountains. Raptor surveys were conducted in the project area prior to mining activity (DSL 1979a), and several reconnaissance-level surveys for nesting raptors have been conducted between 1979 and mid-March 1991 (Westech 1985, 1986, 1989). The most recent survey for nesting raptors was conducted in spring 1990 (Westech 1991) and included areas such as proposed disturbance areas under the CPA and forest and riparian habitat along Alder, Ruby, Pony, Goslin, Mill, Montana, and Beaver Gulches and Bull and Lodgepole Creeks (Westech 1991, Farmer 1994). An element occurrence search conducted by the MNHP on December 19, 1994 found no northern goshawks reported within Phillips County (Hinshaw 1994). Golden eagles; red-tailed, ferruginous, and rough-legged hawks; American kestrel; and great-horned owls are common at various times of the year (Westech 1991). Other raptors such as Cooper's hawk, northern goshawk, and prairie falcon are occasionally observed. No raptor nests have been documented within the proposed project area; however, fledgling raptors have been observed near the mine site, suggesting nearby nesting. Suitable raptor nest sites are apparent in surrounding drainages.

Bats

Six species of bats have been documented to use Azure Cave. It is one of several hibernaculums in the Pacific Northwest, and may be the northernmost in the United States (Chester et al. 1979). An initial resource inventory and evaluation of the cave, performed in 1978, documented use of the cave by about 530 bats of several species, including little brown bat *(Myotis lucifugus)* and long-legged myotis (Chester et al. 1979). A survey conducted in August 1991 by a U.S. Forest Service biologist identified big brown bat *(Eptesicus fuscus)*, western small-footed myotis, and little brown bat at the cave (Butts 1993). Surveys of Azure Cave in September 1992 documented the presence of big brown bat,

northern long-eared myotis, little brown bat, and Townsend's big-eared bat (Butts 1993).

Winter surveys conducted in March 1993 documented the presence of 250-300 little brown bats, 11 Townsend's big-eared bats, and one long-legged myotis (Butts 1993). This survey was aborted before the entire cave could be surveyed to avoid undue disturbance to hibernating bats; however, most portions of the cave likely to contain bats were surveyed. Azure Cave supports a bat hibernaculum of both local and national significance (Chester et al. 1979). The cave provides temperature and humidity ranges essential to the survival of at least 3 and likely 5 species of hibernating bats (Butts 1993). Hibernating bats must not deplete their fat reserves prior to the end of winter. Disturbance resulting in movement requires heavy expenditure of energy and fat reserves (Yalden and Morris 1975); thus, mid-winter disturbance can pose a severe threat to bats in Azure Cave.

3.5.2 Aquatic Species

Fisheries habitat in the Little Rocky Mountains is very limited (Westech 1991; BLM 1972). Brook trout inhabit Beaver, Lodgepole, and Little Peoples Creeks, and can be found in ponds along lower Rock Creek; rainbow trout occur in Little Peoples Creek (Westech 1991). All other drainages in the project area, including Ruby, Alder, and Montana Gulches, have mostly intermittent flows and thus do not support a fishery. Because of these intermittent flows, aquatic macroinvertebrate populations prior to 1979 would have been limited in upper reaches of all drainages and in Ruby Gulch, even below the town of Zortman. The MDFWP conducted inventories on fish populations in reservoirs and perennial flowing portions of Rock Creek south of Landusky (DSL/BLM 1993c). Non-salmonid fish populations found include flat-headed minnows, long-nose dace, white sucker, northern redbelly dace, brook stickleback, northern pike, and perch. These studies concentrated on the lower reaches of Rock Creek, due to the fact that the stream often runs dry near Landusky and is not a perennial flowing stream until it is fed by springs which occur in drainages south of the mountains (DSL/BLM 1993b).

Ten streams in the vicinity of proposed and existing mining operations were sampled for macroinvertebrates in June 1990 and seasonally in 1991 (Westech 1991). The ten streams surveyed included:

- Beaver Creek
- Upper Lodgepole Creek
- Lower Lodgepole Creek
- Alder Gulch
- Mill Gulch
- Rock Creek
- Montana Gulch
- Bull Gulch
- Big Horn Creek
- King Creek

Based on these two years of sampling, macroinvertebrate populations in the project area are relatively insubstantial. Fifty-one taxa of aquatic macroinvertebrates were identified during this study, with mayflies and stoneflies accounting for more than half the organisms collected. The most common taxa identified included mayflies (*Baetis* sp. and *Epeorus* sp.), stoneflies (Nemouridae), fly larvae (Chironomidae and Simuliidae), flatworm (Turbellaria), the stonefly *Sweltsa/Suwallia* sp., and the mayfly (*Cinygmula* sp.). Overall low total macroinvertebrate numbers, low diversity of taxa and an abundance of pollution tolerant organisms are reflective of natural perturbations and previous mining activities still affecting streams in the area. Extreme annual fluctuations in runoff and discharge maintenance contribute to erratic population numbers annually and seasonally. The "cleanest", "healthiest" streams in the project area, in terms of being able to maintain a relatively abundant, diverse population of macroinvertebrates annually, are Beaver and Lodgepole Creeks. Although subject to fluctuating water levels, these two streams maintain sufficient water to support benthic populations throughout the year, and appear less affected by historical mining operations.

3.5.3 Reptiles and Amphibians

Very few reptiles or amphibians were noted in the Little Rocky Mountains during pre-mine inventory and wildlife monitoring studies from 1977 to 1990. Species observed included a racer (*Coluber constrictor*) in ponderosa pine/grassland near Montana Gulch, a western garter snake (*Thamnophis elegans*) along a deciduous streambank in Alder Gulch, boreal chorus frog (*Pseudacris triseriata*) and a leopard frog (*Rana pipiens*) in Montana Gulch (Farmer 1977, Westech 1990). Other reptiles and amphibians potentially found in the study area include the plains hognose (*Heterodon nasicus*), bull snake (*Pituophis melanoleucas*), milk snake (*Lampropeltis triangulum*), prairie rattlesnake (*Cortalus viridis*), tiger salamander (*Ambystoma triginum*), and Rocky Mountain (Woodhouse's) toad (*Bufo woodhousei*). None of these is considered a special status species.

3.6 AIR QUALITY AND METEOROLOGY

3.6.1 Air Quality

3.6.1.1 General Conditions

Air resources in the project area are generally of good quality. No data is available from DEQ files or ZMI prior to 1990. The previous mining operating permits have required collection and reporting of air quality data since 1985, but it is unclear if such data was ever collected or reported. Monitoring data concerning respirable particulates (PM_{10}) were collected from March 1990 to April 1995 at up to 10 locations within the project area. These data are summarized in Tables 3.6-1 through 3.6.6. The maximum 24-hour PM_{10} concentrations in the area ranged from 19 $\mu g/m^3$ at Site 9 in 1992, to 102 $\mu g/m^3$ recorded at Site 5, in 1992. Annual average values ranged from 8 $\mu g/m^3$ at several locations to 16 $\mu g/m^3$ at Site 3.

There was no air quality collected in the project area prior to the beginning of mining operations. The air quality data in Tables 3.6-1 through 3.6.6, Site meteorological data, and mining activities were reviewed to determine what data is most representative of background conditions in the Zortman/Landusky area. Data from Sites 7, 8, 9, and 10 are believed to be typical of the background conditions and concentrations measured at Site 7 in 1994 were selected to represent background conditions. Site 7 was selected because it is the closest to Zortman and Landusky of the four possible monitoring stations. The measured concentrations from Site 7 in 1994 are 30 $\mu g/m^3$ as a 24-hour average and 9 $\mu g/m^3$ as an annual average.

Note that the Montana and federal *24-hour* ambient air quality standard for PM_{10} is 150 $\mu g/m^3$, and is not to be exceeded more than once per year. The *annual* Montana and federal standard is 50 $\mu g/m^3$. The background concentrations selected are below the Montana and federal ambient air quality standards.

3.6.1.2 Existing Air Emission Point Sources

Other air quality sources in the area include gold processing activities and particulate emissions from private vehicles and fireplaces.

The gold processing sources include (1) lead emissions from the assay lab located in the town of Zortman; (2) emissions from the refinery at the Zortman Mine process plant; and (3) hydrogen cyanide gas emissions from the various Zortman and Landusky leach pads. Each of these sources and their nature are discussed below.

Lead air emissions from the assay lab have been estimated by the Montana Air Quality Division (AQD 1994a) at approximately 504 pounds per year (0.25 tons per year) based on the current lab operating schedule of 8 hours per day. An air quality permit is not required until lead emissions are greater than 5 tons per year. Ambient air lead concentrations in the town of Zortman were analyzed from the PM_{10} samples taken at the town of Zortman air quality monitoring location (Figure 3.6-1). This monitoring station is located within a few hundred yards of the assay lab. The maximum lead concentration measured at this monitoring location was 0.03 $\mu g/m^3$. This concentration is below the Montana and federal ambient air quality standard for lead of 1.5 $\mu g/m^3$. The Montana standard is for a 90 day period, the federal standard is for a quarter.

Stack testing of emissions from the refinery indicate a total particulate emission of 2.42 tons per year (AQD 1994a). An EPA-approved model called SCREEN was used to estimate the ambient air concentrations at the town of Zortman resulting from the refinery emissions. Modeling results estimate a 24-hour and annual PM_{10} concentration of 1.4 $\mu g/m^3$ and 0.3 $\mu g/m^3$, respectively. These concentrations are below applicable Montana and federal ambient PM_{10} standards.

Emissions of hydrogen cyanide from the leach pads at the Landusky Mine were measured by ZMI personnel in early 1990 (DSL/BLM 1991b). Hydrogen cyanide concentrations did not exceed 1 ppm. Industry-wide measurements of hydrogen cyanide in ambient air near working leach pads show average concentrations of 2 to 3 ppm (NPS 1986). The Threshold Limit Value for hydrogen cyanide is 10 ppm (ACGIH 1993). Hydrogen cyanide at 110 ppm is fatal after one hour. At 270 ppm, it is immediately fatal.

Particulate air emissions in the project also occur from the operation of private vehicles and woodburning. Impacts from these sources are included in the monitoring data presented in Tables 3.6-1 through 3.6-6.

3.6.2 Climate and Meteorology

The climate of the Little Rocky Mountains in north-central Montana is classified as semi-arid continental. Features of this climate include cold winters, warm summers, wide temperature extremes, annual precipitation totals of 11 to 40 inches, and abundant sunshine.

TABLE 3.6-1
MAXIMUM AND AVERAGE PM_{10} CONCENTRATIONS ($\mu g/m^3$) FOR THE PROJECT AREA
(January 1990 - December 1990)

Site	Maximum	Second Highest	Arithmetic Average
1	28	28	11
2	31	25	13
3	41	41	15
5	42	34	15
6	48	39	15
7	26	17	11

TABLE 3.6-2
MAXIMUM AND AVERAGE PM_{10} CONCENTRATIONS ($\mu g/m^3$) FOR THE PROJECT AREA
(January 1991 - December 1991)

Site	Maximum	Second Highest	Arithmetic Average
1	32	23	8
2	35	32	10
3A	70	61	16
3B	48	26	14
5	35	31	9
6	31	22	9
7	33	20	10

Site 1: Upwind of the Zortman and Landusky Mines
Site 2: Town of Landusky
Site 3: Downwind of Landusky Mine at Sullivan Park
Site 5: Downwind of the Zortman Mine, SE of the Zortman School
Site 6: East of Zortman
Site 7: Seven Mile Road

Note: Sites 3A and 3B were co-located samplers for a period of time at Sullivan Park.

Source: Gelhaus 1994.

TABLE 3.6-3
MAXIMUM AND AVERAGE PM_{10} CONCENTRATIONS ($\mu g/m^3$) FOR THE PROJECT AREA
(January 1992 - December 1992)

Site	Maximum	Second Highest	Arithmetic Average
1	90	25	9
2	96	37	10
3A	101	58	14
3B	99	59	16
5	102	29	9
6	95	24	9
7	29	24	8
8	23	14	6
9	19	18	7
10	29	22	9

Site 1: Upwind of the Zortman and Landusky Mines
Site 2: Town of Landusky
Site 3: Downwind of Landusky Mine at Sullivan Park
Site 5: Downwind of the Zortman Mine, SE of the Zortman School
Site 6: East of Zortman
Site 7: Seven Mile Road
Site 8: Beaver Creek
Site 9: Lodgepole
Site 10: Hays

Source: Gelhaus 1994.

TABLE 3.6-4
MAXIMUM AND AVERAGE PM_{10} CONCENTRATIONS ($\mu g/m^3$) FOR THE PROJECT AREA
(January 1993 - December 1993)

Site	Maximum	Second Highest	Arithmetic Average
1	25	21	9
2	30	27	10
3A	30	29	12
3B	29	29	9
5	28	21	9
6	24	24	9
7	24	23	9
8	30	23	9
9	22	21	10
10	26	24	10

Site 1: Upwind of the Zortman and Landusky Mines
Site 2: Town of Landusky
Site 3: Alder Gulch (April-December)
Site 5: Downwind of the Zortman Mine, SE of the Zortman School
Site 6: East of Zortman
Site 7: Seven Mile Road
Site 8: Beaver Creek
Site 9: Lodgepole
Site 10: Hays

* Site 3 was relocated to Upper Alder Gulch on April 1, 1993.

Source: Gelhaus 1994.

TABLE 3.6-5
MAXIMUM AND AVERAGE PM_{10} CONCENTRATIONS ($\mu g/m^3$) FOR THE PROJECT AREA
(January 1994 - December 1994)

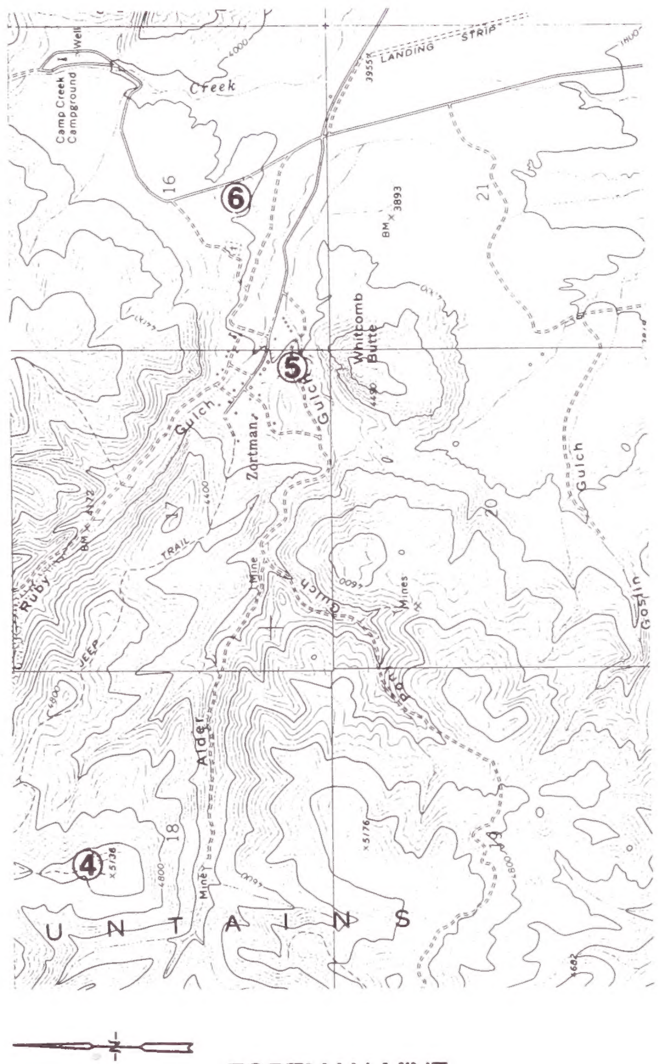
Site	Maximum	Second Highest	Arithmetic Average
1	37	35	10
2	75	55	15
3A	75	62	16
3B	78	68	16
5	35	34	11
7	30	28	9
8	30	27	8
9	65	43	11
10	37	33	12

TABLE 3.6-6
MAXIMUM AND AVERAGE PM_{10} CONCENTRATIONS ($\mu g/m^3$) FOR THE PROJECT AREA
(January 1995 - September 1995)

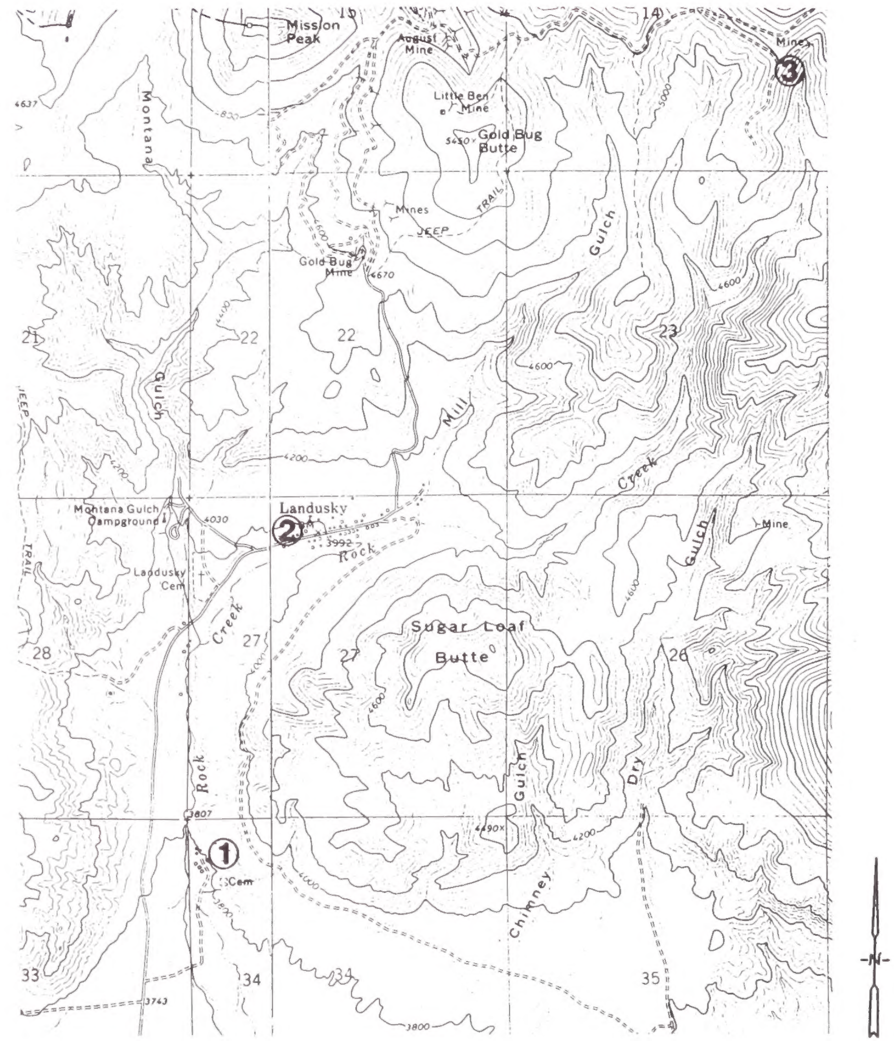
Site	Maximum	Second Highest	Arithmetic Average
1	20	18	8
2	50	40	12
3A	29	23	9
3B	22	22	8
5	23	21	9

Site 1: Upwind of the Zortman and Landusky Mines
Site 2: Town of Landusky
Site 3: Upper Alder Gulch
Site 5: Downwind of the Zortman Mine, SE of the Zortman School
Site 6: East of Zortman
Site 7: Seven Mile Road
Site 8: Beaver Creek
Site 9: Lodgepole
Site 10: Hays

Source: Gelhaus 1994.



ZORTMAN MINE



LANDUSKY MINE

ZORTMAN AND LANDUSKY MINES
AIR QUALITY MONITORING SITES

FIG. 3.6-1

Meteorological data were collected at three locations in the project area. Site-specific meteorological data from April 1990 to September 1991 are summarized in Tables 3.6-4, 3.6-5, and 3-6.6. For comparison, regional 25-year climatological averages of temperature and precipitation are presented in Tables 3.6-7 and 3.6-8, respectively. Figure 3.6-2 presents the wind rose for the Zortman Mine Boneyard meteorological station. The wind rose depicts the percentage of time that the wind blows from a particular direction in a certain wind speed class. The most common wind direction was from the west northwest, which occurred 25 percent of the time during the monitoring year. Table 3.6-4 summarizes average wind speed and most frequent wind direction by month at the Sullivan Park, the Zortman Mine Boneyard, and the Seven Mile Road meteorological stations. The Seven Mile Road station exhibited a more northerly wind flow than the other stations, especially in the summer. Average wind speeds at all three stations were fairly strong, averaging approximately 11 mph for the monitoring period. The monthly average wind speed at the Zortman Mine Station ranged from 5.5 mph in May to 17.2 mph in December. At the Sullivan Park Station, monthly average wind speeds ranged from 9.7 mph in August to 14.1 mph in November. Monthly average wind speeds at the Seven Mile Road station ranged from 7.6 mph in September to 14.8 mph in November and December.

Monthly temperature means and extremes for the immediate project area for the monitoring period May 1990 to September 1991 are presented in Table 3.6-5. Monthly temperature means for the project location are somewhat lower than the climatological averages for the region, due to the higher elevation of the project area. The range of monthly mean temperatures in the project area was from 12.2° F in December to 68.0° F in August. The lowest temperature recorded in the project area was -31° F at Sullivan Park in December and the highest temperature was 88° F, recorded at both stations in August.

Regional monthly temperature means and extremes representing 25-year climatological averages are presented in Table 3.6-7. Monthly mean temperatures in the region range from 9.2° F in January to 70.5° F in July. Temperatures can get as cold as -50° F in the winter months and as high as 111° F in the summer months, although these extremes of temperature rarely last for long periods of time.

The 25-year climatological average annual precipitation range from 10.87 inches in Glasgow to 17.20 inches in Lewistown (see Table 3.6-8). Mountainous locations in the region receive as much as 40 inches per year. The majority of the rainfall occurs in late spring and summer. The wettest month is June, averaging from 2.55 inches in Havre to 3.47 inches in Lewistown. February is the driest month, averaging 0.32 inches in Glasgow to 0.60 inches in Lewistown. Snowfall amounts in the area vary with elevation, with the mountainous areas receiving higher amounts.

Monthly precipitation totals for the immediate project area are presented in Table 3.6-6 and cover the monitoring period of July 1990 through September 1991. The range of monthly total precipitation amounts in the project area was from 0.13 inches in September 1990 to 7.54 inches in June 1991. Most of the rainfall in the project area occurs from April through June.

Table 3.6-9 presents additional precipitation and storm event data for the project area. Table 3.6-9 summarizes 6 years of precipitation data collected at the Bureau of Land Management-operated RAWS weather station near the Zortman Mine. The maximum annual precipitation recorded at this station was 19.7 inches, occurring in 1989. The highest monthly precipitation total was 8.0 inches, occurring in June 1991, and the highest 24-hour precipitation total was 5.5 inches, recorded in May 1988. The design storm event for the Zortman, Montana area has been calculated by the DEQ at 6.0 inches, and may have been approached at the project site during June 1993 when several short-duration, intense storm events resulted in 1/2 inch to 1 inch of rain in less than one hour (DSL 1993b).

The area therefore is characterized by high precipitation in the early summer months, with storm flows capable of causing stresses to constructed waste piles, heap leaches, drainage ditches, and retention ponds, as confirmed by field visits following the June 1993 event.

TABLE 3.6-7
REGIONAL TEMPERATURE MEANS AND EXTREMES (°F)
25-Year Climatological Averages

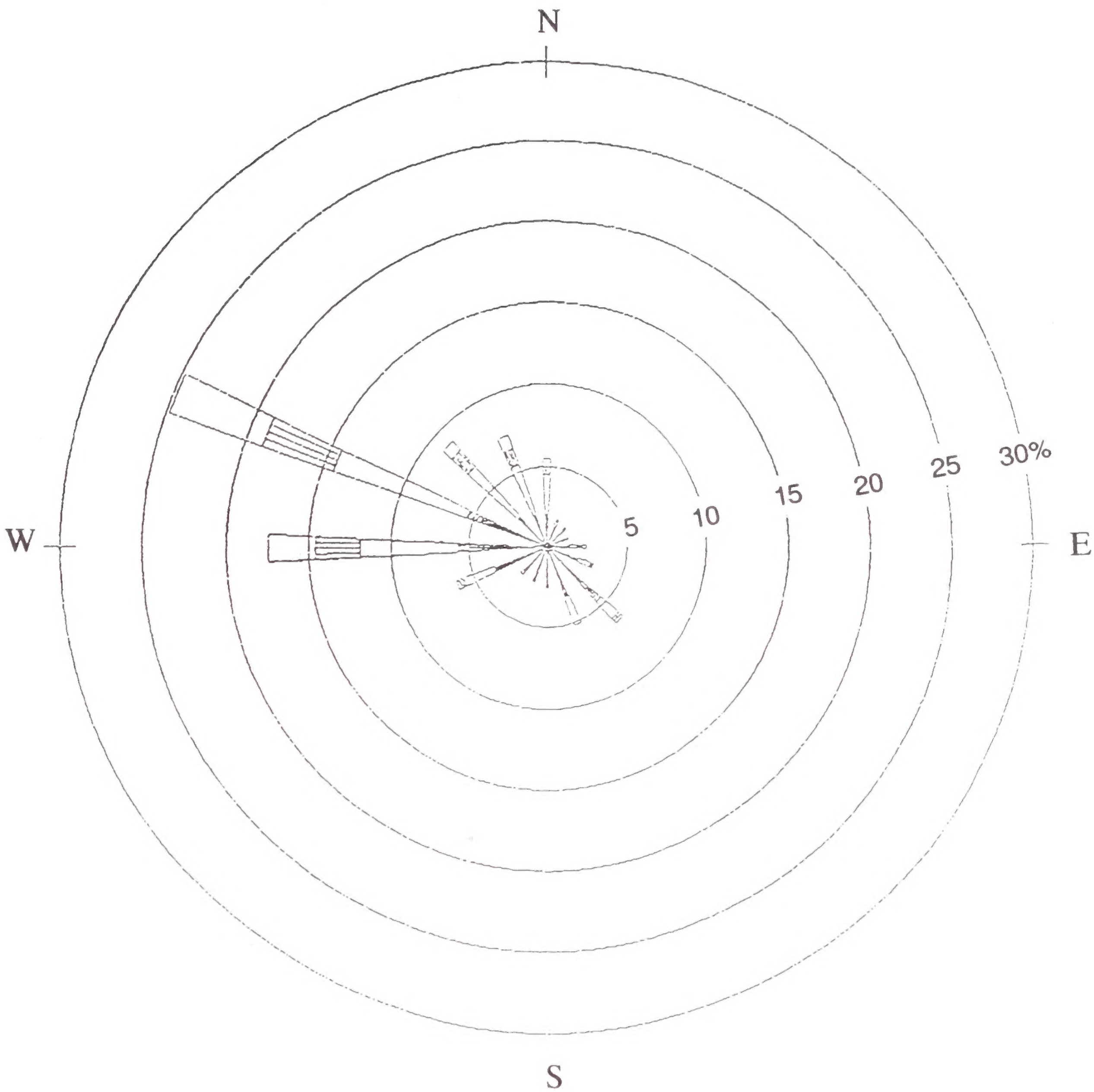
Month	Glasgow, MT			Havre, MT			Lewistown, MT		
	Monthly Mean	Maximum	Minimum	Monthly Mean	Maximum	Minimum	Monthly Mean	Maximum	Minimum
January	9.2	55	-47	11.3	63	-52	18.9	65	-38
February	15.2	59	-37	17.6	67	-30	24.8	63	-31
March	25.2	75	-27	26.5	75	-24	28.3	73	-28
April	42.8	88	-3	43.6	87	-14	39.5	83	-2
May	54.2	95	20	54.9	94	24	49.7	89	14
June	62.0	98	33	62.1	100	32	57.7	93	23
July	70.5	104	41	69.9	106	39	65.5	100	33
August	69.0	106	37	68.0	111	36	65.1	103	33
September	57.2	99	21	57.1	101	20	54.1	96	19
October	46.4	88	5	46.6	88	0	45.4	89	-8
November	29.0	75	-21	30.0	78	-23	32.4	72	-29
December	17.1	56	-37	18.2	65	-46	24.5	65	-41
Annual	41.5	106	-47	42.2	111	-52	42.2	103	-41

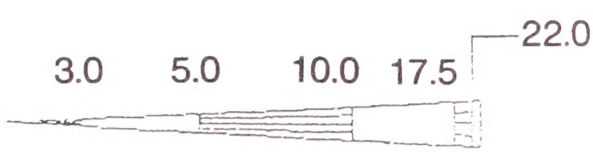
Source: NOAA 1982.

TABLE 3.6-8
REGIONAL MEAN PRECIPITATION (inches)
25-year Climatological Averages

	Glasgow	Havre	Lewistown
January	0.39	0.52	0.81
February	0.32	0.40	0.60
March	0.37	0.49	0.72
April	0.71	1.02	1.21
May	1.31	1.48	3.26
June	2.72	2.55	3.47
July	1.43	1.38	1.45
August	1.51	1.05	1.94
September	0.85	1.11	1.39
October	0.56	0.67	1.00
November	0.39	0.46	0.65
December	0.31	0.42	0.70
Annual	10.87	11.55	17.20

Source: NOAA 1982.





WIND SPEED CLASS BOUNDARIES

(MILES/HOUR)

NOTES:

DIAGRAM OF THE FREQUENCY OF OCCURENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE - WIND IS BLOWING FROM THE NORTH 5.5 PERCENT OF THE TIME.

WINDROSE

ZORTMAN MINE

BONEYARD METEOROLOGY STATION

PERIOD: 1990-91

FIGURE 3.6-2

TABLE 3.6-9
PRECIPITATION AND STORM EVENT DATA COLLECTED AT THE ZORTMAN MINE METEOROLOGICAL (RAWS) STATION

	1987	1988	1989	1990	1991	1992
Total Precipitation (inches)	10.9	15.2	19.7	11.3	17.2	16.4
Monthly Max. (inches)	3.6	6.5	5.9	4.3	8.0	5.0
Month	May	May	May	May	June	June
24-hour Max. (inches)	1.9	5.5	1.1	0.9	1.9	1.6
Date	May 27	May 7	Jun 11 Nov 4	May 24	Jun 29	Jun 16
Data Recovery (percent)	57	96	95	97	96	94

Source: BLM 1995a.

3.7 RECREATION AND LAND USE

This section will identify recreation and land use resources in the study area which could be affected, either directly or indirectly, by the proposed expansion and reclamation plans for the Zortman and Landusky mines. Information was compiled from maps and literature supplied by public and private agencies and telephone communications with federal, state, and Native American agencies.

Public lands in the vicinity of the Zortman and Landusky mines provide both developed and dispersed recreational opportunities. Prior to 1979, recreation use included the Montana Gulch campground near Landusky and the Camp Creek campground near Zortman. Both campgrounds were well used, especially on weekends during the summer and fall seasons. In 1976 a well was drilled at the Montana Gulch campground. Water samples from that well showed the groundwater to contain elevated concentrations of arsenic. The well was capped and not available for public use. Historic mining was the most likely cause of the groundwater contamination. Dispersed recreation activities included camping, picnicking, hiking, sightseeing, off-road vehicles use and hunting. Recreationists could access the Zortman to Landusky county road over Antoine Butte which is currently off limits to non-mine vehicles.

Currently, the Camp Creek Campground and associated Buffington day use area, and the Montana Gulch campground are still developed sites managed by the BLM. Figure 3.7-1 shows the location of major recreation resources near the project area. In 1992 there were approximately 500 visits at the Montana Gulch campground and 2,400 visits at the Camp Creek facilities (900 visits to the campground and 1,500 visits at the day use area).

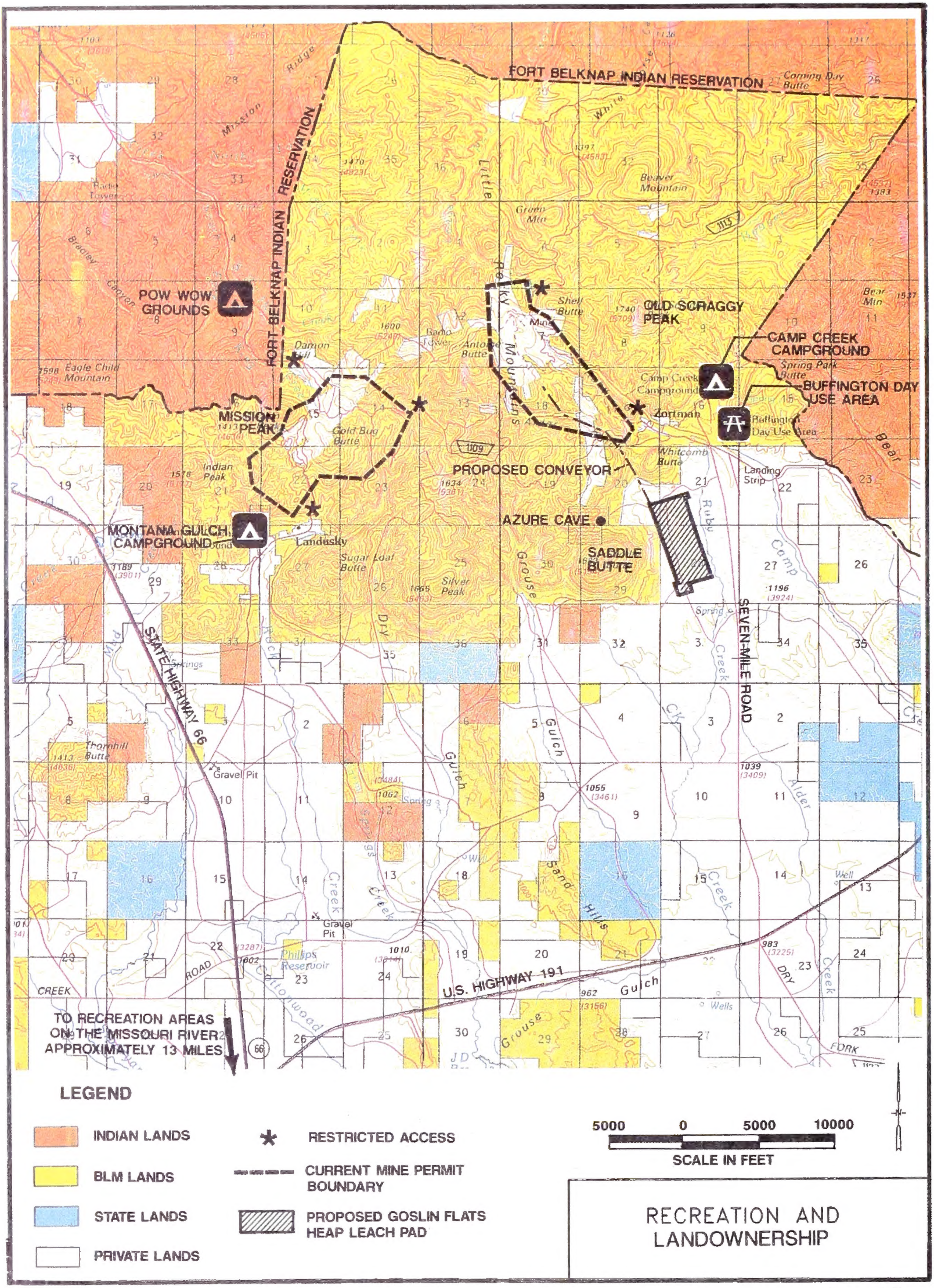
The Camp Creek Campground, and the area surrounding the campground, is a designated watchable wildlife area. This is a program, participated in by many federal and state agencies, that identifies areas which may provide the public with opportunities for viewing wildlife. The area surrounding the Camp Creek campground provides good habitat for songbirds. Currently there are minimum facilities associated with the wildlife area but the BLM has future plans for an interpretive display describing the wildlife that can be observed in the area.

The Phillips Resource Area contains three Recreation Management Areas (RMAs). BLM land within the Phillips Resource Area provided an estimated 29,600 recreation visits in 1992 (Whitehead 1995). The Little Rocky Mountain RMA, which encompasses approximately 25,800 acres of public land, is in the area of the Zortman and Landusky mines. An estimated 7,000 visits occur annually on BLM lands within this RMA. Primary dispersed uses include hiking, horseback riding, mountain biking, all-terrain vehicle (ATV) use, wildlife/bird watching, caving, climbing and hunting. These activities occur in many locations in the Little Rocky Mountains, including many of the roads, trails and mountains in the vicinity of the Zortman and Landusky mines. Sightseeing (i.e., walking, biking, or driving on the access roads and trails throughout the area) and picnicking account for the majority of the use, with approximately 3,000 visits. BLM lands are open to off-road vehicle use on designated roads and trails. Zortman Mining Inc. gives tours of their mine operations. There were 360 visitors to the mines in 1992; 225 in 1993; and 92 in 1994.

The Azure Cave, located on the north side of Saddle Butte, has been designated as an Area of Critical Environmental Concern (ACEC) by the BLM, because of its unique geological and biological resources (see Section 3.13). Currently recreational use of Azure Cave is not allowed. A few caving groups have been granted access for inventory of cave features but access is very limited. Saddle Butte is used by recreationists for hiking and wildlife watching. Pony Gulch, a side canyon to Alder Gulch, is used in the winter for Christmas tree cutting. The access roads to both Saddle Butte and Pony Gulch would be crossed by the proposed conveyor route. Old Scraggy Peak, located approximately one mile east of the existing mine, provides semi-technical climbing opportunities, and is used by local climbers.

Mule deer hunting is the primary hunting use of the area, although on the plains south of the mountains prairie dog hunting is a very popular activity. Bighorn sheep, elk, and mountain lions are hunted within the Little Rocky Mountains. An outfitter based in Zortman provides guiding and outfitting services. Hunting is not a major recreation activity in the area, with use estimated at 200 visits annually.

In recent years the Fort Belknap Indian Reservation has made an effort to provide more recreational facilities to attract tourists and recreationists. Mission Canyon, located several miles north of the Landusky Mine, contains campgrounds, picnic areas, informational signing, a natural bridge, and an area used for Pow Wows. The Pow Wow grounds are located near the upper end of the South Fork of Little Peoples Creek. Participants in the Pow Wows come from many different tribes within Montana and surrounding states; Pow Wows are held several times a year. Portions of the



RECREATION AND LANDOWNERSHIP

FIG. 3.7-1

Landusky mine can be seen from the Pow Wow grounds and from several viewpoints along the upper sections of Mission Canyon Road. The Zortman mine is not visible from the Pow Wow grounds or other developed recreation facilities, although would be visible from viewpoints on the higher mountains and buttes which may be used for hiking and other uses.

The Missouri River, located over 20 miles south of the Zortman Mine, provides numerous recreational opportunities. West of U.S. Highway 191, a stretch of the Missouri River is a designated Wild and Scenic River. Recreational opportunities include floating, boating, hiking, dispersed camping, fishing, and wildlife watching. Two BLM Wilderness Study Areas (WSAs), Cow Creek (34,050 acres) and Antelope Creek (12,350 acres), are located north of the Missouri River, approximately 10 miles southeast from the Zortman and Landusky mines. Approximately 9,600 acres within the Antelope Creek WSA and 21,590 acres within the Cow Creek WSA have been recommended as suitable for wilderness designation. BLM management direction is to manage these lands to maintain their wilderness values. Mining activity in the Little Rocky Mountains, including portions of the Landusky and Zortman mines, can occasionally be seen from high ground within the WSAs.

A portion of the Nez Perce National Historic Trail (NPNHT) is located along the Missouri River and the Cow Creek WSA. The Lewis and Clark National Historic Trail (LCNHT) runs the length of the Missouri River south of the study area. Both of these trails provide interpretive opportunities and are managed to protect their scenic and cultural values. The Cow Creek ACEC (14,000 acres) is located on the west side of the Cow Creek WSA. It includes segments of the NPNHT, LCNHT and Cow Island Trail. The area is managed for scenic, interpretive, recreational and paleontological values. An 80-mile, self-guided tour route, the Missouri Breaks Backcountry Byway, traverses the badlands topography south of the Missouri River. Several points of interest along the route include views of the Little Rocky Mountains and the Landusky mine.

The western portion of the Charles M. Russell National Wildlife Refuge (CMR) is located approximately 15 miles south of the Zortman Mine site. The CMR is managed by the USFWS. The CMR management objective is to preserve, restore and manage portions of the nationally significant Missouri River Breaks and associated ecosystems for wildlife resources and compatible human uses associated with wildlife and wildlands.

Big game hunting is the most popular recreational use on the CMR. Hunting for big game takes place between the first week of September and the last week of November, and includes both archery and rifle hunting. Other dispersed recreation activities occurring on the CMR include fishing (especially in the spring after the ice melts off the river), boating, canoeing, hiking, photography and wildlife viewing. A 20-mile, self-guided auto tour route starts on State Highway 191 just north of the Missouri River and travels east along the river for approximately six miles before turning north along Bell Ridge and heading back to State Highway 191. An estimated 5,000 people use the auto tour route annually. Mining operations in the Little Rocky Mountains are visible from several locations along the higher ridges within the CMR, but are not visible from recreation sites along the river itself.

Developed recreation sites in the western portion of the CMR include the James Kipp Recreation Area, Rock Creek and Turkey Joe recreation sites. The James Kipp site is managed by the BLM, the Rock Creek and Turkey Joe sites are managed by the USFWS. The takeout point of the Upper Missouri National Wild and Scenic River is located at the James Kipp site. In 1991, the BLM estimated 55,000 visitor days at James Kipp.

The 1992 Judith-Valley-Phillips Resource Management Plan (RMP) details the land use management guidelines for BLM lands in the Little Rocky Mountains. Figure 3.7-1 shows the location of public lands managed by BLM, and other land ownership in the project area. Briefly, decisions made in the RMP that pertain directly to the Little Rocky Mountains state that the area is:

- Closed to oil and gas leasing;
- Open to locatable minerals except for approximately 260 acres;
- Available for mineral material disposal;
- Closed to livestock grazing except for two temporary permits;
- Generally open to off-road vehicles. However, use is restricted to designated roads and trails in the Camp Creek and Montana Gulch campgrounds, and the Azure Cave ACEC; and
- A Recreation Management Area with two campgrounds, one recreation site, and dispersed recreation opportunities.

In addition,

- Communication sites are confined to Antoine Butte;
- Intensive fire suppression for the recreation and communication sites will be employed;

- 26,240 acres are bighorn sheep habitat
- Public lands are not identified for disposal with the exception of the Zortman and Landusky townsites; and
- The Azure cave was designated as an ACEC (140 acres).

More detailed information can be found in the RMP. The post-mine land use objective for the Zortman and Landusky mines are for those lands to return to productive multiple uses. Objectives are to reclaim the lands disturbed by mining activity to: maintain and enhance wildlife habitat; to develop and maintain opportunities for dispersed recreation including hiking, scenic and wildlife viewing, and hunting; to improve the visual quality of disturbed lands, and; to improve and maintain the general ecological condition of watersheds, including soil productivity, surface and groundwater quality and vegetation.

Agriculture is the predominant land use occurring in Phillips and Blaine counties. Within Phillips County, rangeland and cropland account for approximately 97.5 percent of land use with woodland, water areas, urban and built-up areas, roads, and non-farm residences accounting for the remaining 2.5 percent. Land in Phillips County is zoned agricultural, except where a special use permit has been approved by the county. Privately-owned lands that would be affected by the proposed heap leach pad and conveyor system are currently used for livestock pasture. These lands are currently owned by ZMI and are being leased to local ranchers.

3.8 VISUAL RESOURCES

3.8.1 Study Area and Methodology

This section identifies and describes the visual resources which could be affected by the proposed project. The study area includes those areas that viewers may travel through, recreate in, or reside in, or where existing views may be affected by the proposed action.

The description of the visual resources of the study area are based on the methodology described in the BLM's Visual Resource Inventory Manual (BLM 1986b). The visual inventory consists of three factors: (1) a scenic quality evaluation, (2) a sensitivity analysis, and (3) distance zone analysis. The scenic quality evaluation involves the rating of the scenic beauty of an area, which takes into consideration such factors as landform, vegetation, water, color, adjacent scenery, scarcity and cultural modifications. Sensitivity analysis is a measure of the public's concern for the scenic quality of an area, and is based on factors such as number of viewers, type of users (e.g., commuters or recreationists), public interest, and adjacent land use. Landscapes are also classified into distance zones based on visibility from travel routes or other possible sensitive viewing locations. Three distance zones are noted, including the foreground/middleground (0-5 miles), background (5-15 miles), and a seldom-seen zone (>15 miles or not seen).

Based on these three factors, lands are placed into one of four resource inventory classes. These Visual Resource Management (VRM) classes represent the relative value of the visual resource and provide a basis for considering visual values in the resource management planning process. Each VRM class has specific visual objectives defining how the visual environment is to be managed, with VRM Class I the most protective of the resource, and VRM Class IV allowing the most modification to the existing character of the landscape. The objective of each class is defined as follows (BLM 1986b):

- Class I is intended to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.

- Class II is intended to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

- Class III is intended to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural r\features of the characteristic landscape.

- Class IV is intended to provide for management activities which require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements.

3.8.2 Baseline Conditions

The study area is in the Missouri Plateau section of the Great Plains physiographic province (Fenneman 1931). Located between the Missouri and Milk Rivers, the Little Rocky Mountains are an isolated group of domed mountains in an area roughly 10 miles in diameter. Their rounded crests rise nearly 3,000 feet above the surrounding plain, with steeply tilted hogbacks encircling the higher mountains. The topographic relief, colors, and textures of the mountains and their vegetation provide a contrast to the relatively homogenous terrain, lines, forms, colors and textures of the adjacent plains. In an assessment of the visual quality of the Little Rocky Mountains done by the BLM in 1979, the area was rated as Class A scenery and given a Class II VRM rating. Private lands affected by the proposed project are not included in the BLM visual resource designation.

The project study area includes both prairie grasslands and mountains. The Goslin Flats heap leach pad, a section of the proposed conveyor route, and other possible alternative facilities would be located on the flat to rolling grasslands south and east of Whitcomb and Saddle Buttes. This is an open, generally level landscape with smooth textures and simple, indistinct

lines and forms. Colors in the landscape come primarily from the grasses, and are mostly subtle shades of green during the spring and summer growing season, and shades of brown during the fall and winter seasons. Ruby Creek drainage provides some variation in the terrain and vegetation pattern. This area is highly visible to viewers on both U.S. Highway 191 and the county road (7 miles) leading to the town of Zortman, as well as from several of the surrounding buttes and peaks. Currently, the land is used as pasture and, except for some livestock improvements, is generally undisturbed and natural in appearance.

As the viewer moves up the project area into the foothills and mountains (where the current mining activities at Landusky and Zortman are located), the scenery changes from rolling grasslands to steep slopes and drainage bottoms. The landforms, colors and textures of the landscape have become more varied than the plains, and represent a unique scenic resource within the High Plains province. Forms are more distinct, and range from sharply angular along ridges separating the many drainages, to the more rounded forms of the tops of the buttes. Coniferous vegetation provides year-round green color. The scattered open, grassy areas, rock outcroppings, and areas with dense tree cover provide variation in the overall textures and patterns of the landscape.

Although mountain scenery is of high value within the Little Rocky Mountains, portions of the project site itself have been heavily impacted by historic and modern mine exploration and operation activities. Prior to 1979, which was the year in which modern surface mining operations began at both the Zortman and Landusky mines, surface disturbance associated with historic mining activity was visible in Alder and Ruby Gulches near Zortman and in the area of Gold Bug Butte near Landusky. Visual contrasts were caused by access roads, exploration pits, surface mining, adits and waste rock stockpiles. Visibility of these disturbed areas was generally confined to a small local viewshed and not visible from the main travel routes.

Current disturbances to the landscape include those activities associated with the existing Zortman and Landusky mines. These visual contrasts include open pits, waste rock dumps, heap leach pads, plant facilities, and changes in vegetation pattern caused by logging and forest fires. Roads, built for mine exploration and access, and for past BLM logging and fire-fighting activities, crisscross the surrounding slopes. Contrasts created by the existing facilities include color contrasts between the exposed soil and rocks and the surrounding vegetation, and contrasts caused by the alteration of topography. These contrasts, especially disturbance at the Landusky Mine, are visible from many vantage points in the vicinity of the project area, as well as from more distant viewing locations including areas along the Missouri River over 20 miles to the south, including portions of the Missouri Breaks National Backcountry tour route.

3.9 NOISE

3.9.1 Site-Specific Baseline Noise Measurements

Noise measurements were collected in the project area during March, 1991 to estimate baseline and operational noise levels associated with mining activities. The noise levels were collected along the periphery of the Zortman and Landusky mines, adjacent to mining and leaching operations, and around the town of Landusky. Noise measurements were collected over a 24-hour period using a Larsen Davis Laboratories Model 710 Dosimeter/Sound Level Meter, and were recorded as equivalent continuous noise levels (Leq). This sound level meter meets the instrument standards established by the federal government.

Baseline noise levels were collected on March 10 and 17, 1991 to determine normal ambient levels with minimal contribution from mining activities. During these two monitoring days, mining operations were suspended, with only the Landusky process plant, the Mill Gulch leach pad, and plant and security patrols in operation. Ambient baseline noise levels at study area monitoring locations are presented in Table 3.9-1. For comparison, Table 3.9-2 presents general information for the reader regarding the annual average noise levels associated with activity interference and hearing loss, to protect public health and welfare with an adequate margin of safety. Note that an annual Leq of 55 A-weighted decibels (dBA) or greater is considered to interfere with outdoor activities; and an annual Leq of 70 dBA may cause hearing loss over a 40-year exposure period. The A-weighting scale is used in noise level measurements to approximate the frequency response of the human ear.

The 24-hour Leq noise levels recorded on March 10, 1991 in the project area ranged from 47.8 dBA at the mouth of Rock Creek entering Landusky to 74.4 dBA at the east fenceline of the Landusky 1991 pad. During the March 17, 1991 monitoring period, the range of 24-hour Leq noise levels were from 35.9 dBA at the ridgeline above Ereaux cabin site in Mill Gulch to 96.2 dBA measured at the access road across the 1984 Landusky pad dike. The high value recorded at this site was due to the vehicular traffic using the road during the monitoring period. The second highest 24-hour Leq was 51.3 dBA measured at the Landusky townsite along the north fenceline of the Lewis property.

Although these noise level measurements exceed the criteria outlined in Table 3.9-2, note that project area noise measurements were collected during windy conditions, and the levels in Table 3.9-2 assume calm wind conditions. Winds greater than 10 mph can significantly increase the ambient noise levels, by as much as 10-20 dBA. On March 10, 1991 wind speeds averaged over 29 mph, and on March 17, the average wind speed was approximately 13 mph. Therefore, a major contribution to the ambient noise levels (as much as 10-20 dBA) was likely caused by the windy conditions.

3.9.2 Existing Operational/Blasting Noise Measurements

Additional noise monitoring data were collected on September 18, 1990 at the Fort Belknap Indian Reservation Mission Canyon Pow Wow Grounds. Noise measurements were taken to assess background noise levels and blasting noise levels at the Pow Wow Grounds. Noise levels prior to blasting ranged from 35 dBA to 58 dBA with a 10-minute Leq of 43.6 dBA. The blasting operations took place in the vicinity of the Gold Bug Pit, approximately 2.5 miles from the Pow Wow Grounds. The blasting noise level measured at the Pow Wow Grounds was 65.0 dBA. Another noise measurement was made about halfway from the blast site to the Pow Wow Grounds at the Mission Canyon boundary gate. Blasting noise levels in this area were 89.1 dBA. Noise from the blast lasted approximately 1 to 3 seconds. For reference, blasting noise levels measured at other mines ranged from 115 dBA to 125 dBA at 900 feet from the blast (USFS/DSL/DHES 1992).

Noise levels in the towns of Landusky and Zortman were not collected during this blasting event. However, these noise levels can be estimated using the Pow Wow Grounds data and the estimation of noise reduction with distance of 6 dBA with each doubling of distance. The noise level at Mission Canyon boundary gate, about 1.5 miles from the blast site, was measured at 89.1 dBA. Because the Town of Landusky is about ½ mile closer to the blast site, the estimated noise level is higher (93 dBA) than that measured at the boundary gate. The estimated noise level at the Town of Zortman, about 4 miles from the blast site, is 81 dBA. These noise level approximations are probably higher than actual levels experienced because the elevated terrain between the mines and the towns and meteorological conditions (wind, humidity) would further reduce noise levels. However, conditions such as direct wind from the noise site to the receptor can also result in higher than predicted levels.

TABLE 3.9-1
BASELINE AMBIENT NOISE LEVELS (dBA) MEASURED IN THE PROJECT AREA[1]

Site	Location	March 10, 1991	March 17, 1991
1	East fenceline of the Landusky 1991 pad	74.4	47.5
2	North fenceline of the Landusky 1991 pad	63.1	44.8
3	Below the Rock Creek contingency pond	59.9	43.5
4	At the Mill Gulch contingency pond	54.4	39.8
5	Along the north ridge line adjacent to the Mill Gulch leach pad	66.8	46.8
6	Northwest pit floor island of the Queen Rose Pit	64.7	44.5
7	Mission Canyon gate	54.8	41.8
8	King's Creek Monitoring well location	54.8	---
9	West Timberline of the King's Crerek reclamation project	55.4	41.5
10	Lower east ridge of the Montana Gulch reclamation project	58.6	42.8
11	Access roadway across the 1984 Landusky pad dike	65.1	96.2[2]
12	West fence line of the Landusky 1983 leach pad	65.6	43.3
13	North fenceline of the 1979 Landusky contingency pond	65.7	43.4
14	Along the ridgeline above the Landusky main access gate	61.8	38.6
15	Ridgeline above the Ereaux cabin site in Mill Gulch	50.0	35.9
16	Mouth of Rock Creek entering Landusky	47.8	42.2
17	Landusky townsite along north fenceline of the Lewis property	60.9	42.1
	AVERAGE	60.1	51.3

[1] Mining operations suspended during these measurements.
[2] Noise levels at this location biased by vehicular traffic.

Source: Gelhaus 1991b

TABLE 3.9-2
YEARLY AVERAGE[1] EQUIVALENT SOUND LEVELS IDENTIFIED AS REQUISITE TO PROTECT THE PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY

		Indoor			Outdoor		
	Measure	Activity Interference	Hearing Loss Consideration	To Protect Against Both Effects (b)	Activity Interference	Hearing Loss Consideration	To Protect Against Both Effects (b)
Residential with Outside Space and Farm Residences	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Residential with No Outside Space	L_{dn}	45		45			
	$L_{eq(24)}$		70				
Commercial	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Inside Transportation	$L_{eq(24)}$	(a)	70	(a)			
Industrial	$L_{eq(24)}$(d)	(a)	70	70(c)	(a)	70	70(c)
Hospitals	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Educational	$L_{eq(24)}$	45		45	55		55
	$L_{eq(24)}$(d)		70			70	
Recreational Areas	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Farm Land and General Unpopulated Land	$L_{eq(24)}$				(a)	70	70(c)

Source: EPA 1974.

TABLE 3.9-2 - YEARLY AVERAGE[1] EQUIVALENT SOUND LEVELS
(Concluded)

Code:

(a) Since different types of activities appear to be associated with different levels, identification of a maximum level for activity interference may be difficult except in those circumstances where speech communications is a critical activity.

(b) Based on lowest level.

(c) Based only on hearing loss.

(d) An $L_{eq}(8)$ of 75 dB may be identified in these situations so long as the exposure over the remaining 16 hours per day is low enough to result in a negligible contribution to the 24-hour average, i.e., no greater than L_{eq} or 60 dB.

Note: Explanation of identified level for hearing loss: The exposure period which results in hearing loss at the identified level is 40 years.

[1] Refers to energy rather than arithmetic averages.

L_{dn} - Day/night noise level - Calculation of average noise level with a 10-decibel penalty (increase) added to nighttime levels (11 PM - 7 AM).

3.10 SOCIOECONOMICS

Socioeconomics topics discussed in this section are employment, income, and population, local economic effects of the existing Zortman and Landusky mines, facilities and services, local government fiscal conditions, the direct effect of the existing Zortman and Landusky mines on local government revenue, and social conditions within the study area.

3.10.1 Study Area

The socioeconomics section describes existing conditions and trends in Phillips and Blaine counties and the Fort Belknap Indian Reservation with sub-area descriptions, as required, to address the study area for the proposed extensions of operations and modification of reclamation procedures at the Zortman and Landusky mines.

3.10.2 Economic Conditions

The economy of the study area is based on production, extraction and use of natural resources. These resources include land for agriculture (consisting of both crops and livestock), oil and gas, hardrock minerals, and water and wildlife offering outdoor recreation opportunities. The industries that depend upon these resources are primarily export-based, in that goods and services produced are exported from the study area, providing new dollars to the area's economy. The following sections profile economic conditions in Phillips and Blaine counties and within the Fort Belknap Indian Reservation. The emphasis is on economic conditions that could be affected by the Company Proposed Action (CPA) and alternatives at both the Zortman and Landusky mines.

3.10.2.1 Phillips County

The job base in Phillips County has grown moderately over the past two decades (Table 3.10-1). In 1991, the total number of jobs located in Phillips County was 2,786, which was down about 3 percent from 1990 (2,876) but up about 24 percent from 1970. During the same period, the composition of the economic base has shifted due to a decline in agriculture and an increase in mining. In 1991, agriculture provided 25 percent of all jobs available in Phillips County, down from 37 percent in 1970, while mining provided 15 percent of all jobs available, up from less than one percent in 1970. The shift is even more pronounced when it is measured in terms of earnings, a component of personal income composed of wages and salaries paid to employees, other labor income, and proprietor's income (Table 3.10-1). In 1990 and 1991, agriculture contributed 13 and 7 percent, respectively, of total earnings generated in the county, down from 50 percent in 1970, while mining contributed 31 percent, up from less than one percent. The difference in agriculture's relative contribution to earnings in the years 1990 and 1991 indicates this sector's volatility and dependence on factors such as markets, government programs, and the weather.

In spite of its economic performance, agriculture continues to employ the largest share of employed persons who live in Phillips County according to the 1990 Census. In 1990, 28 percent of employed persons residing in Phillips County held jobs in agriculture. Trade was the second largest employer (18 percent), followed by health and educational services, including those provided by government agencies (13 percent), and business and personal services (12 percent). About 6 percent each of Phillips County's workers were employed in mining, construction, manufacturing, and public administration (Table 3.10-2). Since 1970, unemployment in Phillips County typically has been below the Montana state average (Table 3.10-3). Per capita personal income in Phillips County was $13,680 in 1991 (Table 3.10-4), ranking 43rd out of 56 counties in the state, with 87 percent of the Montana state average and 72 percent of the national average. In real terms (and as adjusted for inflation using the urban Consumer Price Index for all items), per capita income in Phillips County grew an average of one percent per year between 1970 and 1990 (Table 3.10-1).

Note that in 1990 there were many fewer Phillips County residents employed locally in mining (Table 3.10-2) than there were mining jobs held in Phillips County (Table 3.10-1). This indicates that workers commute into Phillips County to work in mining. It also suggests that most Phillips County residents employed locally in mining work for the Zortman and Landusky mines which is the county's largest mining employer. Therefore, the small but important share of the local labor force that depends on mining probably depends most on the Zortman and Landusky mines for employment. Also, the Zortman and Landusky mines are attracting workers from other counties, and may have stimulated in-migration of workers when the number of jobs at the mine increased. A comparison of Tables 3.10-1 and 3.10-2 indicate that, overall, Phillips County is a net importer of workers largely due to the availability of jobs in mining, trades and services.

TABLE 3.10-1
EARNINGS, EMPLOYMENT, AND EARNINGS PER EMPLOYEE IN PHILLIPS COUNTY, 1970-91
(earnings in thousands of 1991 dollars)

	1970	1970%	1980	1980%	1990	1990%	1991	1991%	%Chg '70-91
Earnings - Total	$46,261	100%	$33,573	100%	$50,760	100%	$44,348	100%	-4.1%
Agric. & Agric. Services	$22,976	50%	($2,461)	-7%	$6,590	13%	$3,275	7%	-85.7%
Construction	$1,372	3%	$2,104	6%	$1,590	3%	$1,500	3%	9.4%
Government	$7,110	15%	$6,232	19%	$8,501	17%	$8,328	19%	17.1%
Manufacturing	$575	1%	$1,127	3%	$633	1%	$663	1%	15.2%
Mining	$210	0%	$8,141	24%	$15,177	30%	$13,962	31%	6533.7%
Services	$3,953	9%	$6,194	18%	$7,589	15%	$6,109	14%	54.5%
T.C.P.U. & F.I.R.E.	$3,922	8%	$5,153	15%	$3,956	8%	$3,983	9%	1.6%
Trade	$6,142	13%	$7,083	21%	$6,725	13%	$6,528	15%	6.3%
Employment - Total	2,246	100%	2,574	100%	2,876	100%	2,786	100%	24.0%
Agric. & Agric. Services	838	37%	709	28%	696	24%	687	25%	-18.0%
Construction	56	2%	93	4%	82	3%	82	3%	46.4%
Government	400	18%	343	13%	454	16%	437	16%	9.3%
Manufacturing	35	2%	56	2%	39	1%	42	2%	20.0%
Mining	9	0%	220	9%	432	15%	417	15%	4533.3%
Services	306	14%	437	17%	448	16%	402	14%	31.4%
T.C.P.U. & F.I.R.E.	214	10%	272	11%	240	8%	244	9%	14.0%
Trade	388	17%	444	17%	485	17%	475	17%	22.4%

TABLE 3.10-1 - EARNINGS, EMPLOYMENT, AND EARNINGS/EMPLOYEE (PHILLIPS COUNTY)
(Concluded)

	1970	1970%	1980	1980%	1990	1990%	1991	1991%	%Chg '70-91
Earnings/Employee									
Average	$20.597		$13.043		$17.650		$15.918		-22.7%
Agric. & Agric. Services	$27.418		($3.471)		$9.468		$4.767		-82.6%
Construction	$24.492		$22.622		$19.385		$18.293		-25.3%
Government	$17.776		$18.169		$18.726		$19.057		7.2%
Manufacturing	$16.437		$20.127		$16.223		$15.786		-4.0%
Mining	$23.386		$37.004		$35.131		$33.482		43.2%
Services	$12.919		$14.174		$16.941		$15.197		17.6%
T.C.P.U. & F.I.R.E.	$18.326		$18.945		$16.482		$16.324		-10.9%
Trade	$15.830		$15.953		$13.866		$13.743		-13.2%

Source: BEA Regional Economic Information System on CD-ROM, May 1993 (USDOC 1993). Earnings adjusted for inflation by Planning Information Corporation.

Notes: T.C.P.U. - Transportation, Communication, and Public Utilities
F.I.R.E. - Finance, Insurance, and Real Estate

TABLE 3.10-2
STUDY AREA RESIDENT EMPLOYMENT BY INDUSTRY, 1990

	Phillips County		Blaine County					
			Total		Non-FBIR		FBIR	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct
Employed Persons (aged 16+)	2,304	100%	2,706	100%	2,101	100%	605	100%
Agric. & Agric. Services	635	28%	814	30%	741	35%	73	12%
Mining	136	6%	29	1%	13	1%	16	3%
Construction	128	6%	132	5%	89	4%	43	7%
Manufacturing	69	3%	61	2%	56	3%	5	1%
T.C.P.U.	127	6%	107	4%	87	4%	20	3%
Trade	417	18%	448	17%	390	19%	58	10%
F.I.R.E.	66	3%	76	3%	54	3%	22	4%
Services	275	12%	289	11%	235	11%	54	9%
Health & Education Services	307	13%	541	20%	346	16%	195	32%
Public Administration	144	6%	209	8%	90	4%	119	20%

Source: Census of Population and Housing, 1990

Notes: FBIR - Fort Belknap Indian Reservation
T.C.P.U. - Transportation, Communication, and Public Utilities
F.I.R.E. - Finance, Insurance, and Real Estate
Table presents employed persons who reside in each sub-area of the study area regardless of place of work, which may be in another sub-area of the study are or outside the study area altogether.

TABLE 3.10-3
UNEMPLOYMENT RATES IN THE STUDY AREA, 1970-90
(percentage)

	1970	1980	1990
Montana	4.3	6.1	7.0
Phillips County	4.2	4.2	6.5
Blaine County	10.6	8.5	10.2
Fort Belknap Indian Reservation	NA	41.9	26.9

Sources: 1970 and 1980 data from SDS Economic Consultants 1990 for Montana and Phillips County. Economic Consultants Northwest 1991 for Blaine County and Fort Belknap Reservation. All 1990 data from 1990 Census of Population and Housing Summary Tape File 3 on CD-ROM.

TABLE 3.10-4
PER CAPITA PERSONAL INCOME 1970-91, PHILLIPS & BLAINE COUNTIES
(1991 dollars)

	1970	1980	1990	1991	% Chg. '70-90%
Phillips County	$11,769	$11,104	$14,429	$13,680	23%
Blaine County	$10,680	$10,030	$12,729	$10,534	20%

Source: BEA Regional Economic Information System 1993 (USDOC 1993). Adjusted for inflation by Planning Information Corporation.

3.10.2.2 Blaine County

The job base in Blaine County has remained about the same over the past two decades (Table 3.10-5). The total number of jobs located in Blaine County in 1991 was 2,898 which was down about 4 percent from 1990 and up about 6 percent from 1970. However, the composition of the economic base has shifted due to the decline in the relative importance of agriculture and the increase in government jobs and revenue. In 1991, agriculture provided 26 percent of all jobs available in Blaine County, down from 34 percent in 1970, while government provided 24 percent, up from 20 percent. The trend is more striking when evaluated in terms of earnings (Table 3.10-5). In 1990 and 1991, agricultural sectors contributed 28 and 2 percent, respectively, of total earnings generated in the county, down from 43 percent in 1970, while government contributed 29 and 44 percent of total earnings, up from 20 percent. In Blaine County, as in Phillips County, agricultural earnings have varied considerably from year to year during the study period.

Nevertheless, agriculture continues to employ the largest number of workers living in Blaine County. According to the 1990 Census, 30 percent of employed persons residing in Blaine County held agricultural jobs (Table 3.10-2). Twenty percent of employed persons held jobs in health and educational services (including those provided by government agencies), 17 percent in the trade sectors, and 11 percent in business and personal services. About 8 percent of Blaine County's residents were employed in public administration, and 5 percent were employed in construction. Since 1970, unemployment in Blaine County typically has been higher than the Montana state average (Table 3.10-3). Per capita income in Blaine County was $10,534 in 1991, ranking last in the state, with 67 percent of the state average and 55 percent of the national average. Real per capita income grew less than one percent in 1991 compared to 1990, partly because of a large decline in the number of jobs in the service sector and partly due to inflation (Table 3.10-5; Peacock 1994).

Note that in 1990 there were many more Blaine County residents employed in mining (Table 3.10-2) than there were mining jobs held in Blaine County (Table 3.10-5). This indicates that Blaine County residents commute outside the county to find work in the mining industry. It also suggests that they may be finding mining work at the Zortman and Landusky mines which is located within commuting distance of some Blaine County communities. Therefore, a small but important share of the Blaine County labor force employed in mining depends on the Zortman and Landusky mines for employment. A comparison of the two tables also indicates that overall, Blaine County is a net importer of workers by a small margin due to the availability of jobs in trade and services.

3.10.2.3 Fort Belknap Indian Reservation

About 80 percent of the physical area of the Fort Belknap Indian Reservation is located within Blaine County. This part of the reservation contains the communities of Hays and Lodgepole and about 96 percent of the population residing on the reservation in 1990. The remainder of the physical area and population of the reservation is located within Phillips County. Therefore, socioeconomic statistics for both Blaine and Phillips counties include information about the population on the Fort Belknap Indian Reservation. However, statistics about Blaine County are much more heavily influenced by the reservation population, which was about 34 percent of the total population of Blaine County in 1990. In Phillips County, the reservation population was about 4 percent of the total county population in 1990.

The Fort Belknap Indian Reservation has a limited job base and few private employers. The three largest employers located on the reservation are government agencies. The Fort Belknap Indian Community employs about 135 people, the Fort Belknap Agency of the Bureau of Indian Affairs (BIA) employs about 55 people, and the Indian Health Service of the Department of Health and Human Services employs about 35 people. Many of these jobs are in public administration, health services, and home construction. Other jobs are available in Fort Belknap Indian Community-owned enterprises, the Fort Belknap Gaming Operation bingo hall and the Fort Belknap Kwik-Stop convenience store, and in a few private enterprises scattered about the reservation. Agriculture provides jobs and personal income on the reservation directly through crop and livestock production or through the leasing of land owned by tribal enrollees and residents. The Fort Belknap Indian Community also has invested in off-reservation industrial development in the past (Economic Consultants Northwest 1991).

According to the 1990 Census, 32 percent of employed persons residing on the Fort Belknap Indian Reservation held jobs in health and educational services (including those provided by government agencies), and 20 percent held public administration jobs. Twelve percent of resident workers were employed in

TABLE 3.10-5
EARNINGS, EMPLOYMENT, AND EARNINGS PER EMPLOYEE IN BLAINE COUNTY, 1970-91
(earnings in thousands of 1991 dollars)

	1970	1970%	1980	1980%	1990	1990%	1991
Earnings - Total	$51,870	100%	$35,629	100%	$49,226	100%	$32,967
Agric. & Agric. Services	$22,233	43%	$63	0%	$13,861	28%	$787
Construction	$1,807	3%	$2,824	8%	$1,654	3%	$1,477
Government	$10,408	20%	$12,087	34%	$14,464	29%	$14,404
Manufacturing	$2,028	4%	$193	1%	$466	1%	$569
Mining	$42	0%	$770	2%	$165	0%	$167
Services	$4,444	9%	$7,315	21%	$9,618	20%	$6,001
T.C.P.U. & F.I.R.E.	$2,929	6%	$4,421	12%	$2,665	5%	$3,464
Trade	$7,980	15%	$7,956	22%	$6,333	13%	$6,098
Employment - Total	2,743	100%	2,864	100%	3,012	100%	2,898
Agric. & Agric. Services	921	34%	727	25%	775	26%	761
Construction	95	3%	140	5%	76	3%	7
Government	553	20%	625	22%	700	23%	695
Manufacturing	81	3%	21	1%	20	1%	23
Mining	2	0%	17	1%	4	0%	4
Services	446	16%	538	19%	643	21%	485
T.C.P.U. & F.I.R.E.	156	6%	221	8%	188	6%	240
Trade	489	18%	575	20%	606	20%	612

TABLE 3.10-5 - EARNINGS, EMPLOYMENT, AND EARNINGS PER EMPLOYEE (BLAINE COUNTY)
(Concluded)

	1970	1970%	1980	1980%	1990	1990%	1991
Earnings/Employee							
Average	$18,910		$12,440		$16,343		$11,376
Agric. & Agric. Services	$24,140		$87		$17,885		$1,034
Construction	$19,016		$20,174		$21,766		$18,936
Government	$18,821		$19,340		$20,662		$20,725
Manufacturing	$25,031		$9,208		$23,297		$24,739
Mining	$21,047		$45,302		$41,173		$41,750
Services	$9,965		$13,596		$14,958		$12,373
T.C.P.U. & F.I.R.E.	$18,776		$20,004		$14,177		$14,433
Trade	$16,320		$13,836		$10,451		$9,964

Source: BEA Regional Economic Information System on CD-ROM, May 1993 (USDOC 1993).

Notes: Table presents employment in terms of jobs held in the county, regardless of the place of residence of the persons holding the jobs.
T.C.P.U. - Transportation, Communication, and Public Utilities
F.I.R.E. - Finance, Insurance, and Real Estate

agriculture, 10 percent in trade, 3 percent in business and personal services, and 7 percent in construction (Table 3.10-2).

Unemployment on the Fort Belknap Indian Reservation is very high and much higher than the surrounding counties and state as a whole (Table 3.10-3). However, the level of unemployment on the reservation has declined over the past decade. Unemployed persons were about 27 percent of the labor force in 1990, according to the federal decennial census, down from about 42 percent in 1980. This improvement may be due to the growing importance of government as an employer on the reservation. According to federal census data, about 64 percent of employed persons on the Fort Belknap Indian Reservation worked for government in 1990, up from about 54 percent in 1980. The percentage of employed persons working in the private sector remained about the same between 1980 and 1990.

Income is lower on the reservation compared to other areas, but there also has been some improvement in reservation income level over the past decade. Median family income in 1989 (measured by the 1990 census) was $14,583 in the Fort Belknap Indian Reservation, compared to $26,862 in Phillips County, $21,347 in Blaine County as a whole, and $28,044 in the state of Montana as a whole. Reservation median family income in 1989 was up by about 6 percent in real terms from the 1979 level of $13,812 (as adjusted for inflation and expressed in 1989 dollars). By this measure, the reservation fared better than Blaine County as a whole where 1989 median family income was down by about 16 percent in real terms from the 1979 level of $25,335 (in 1989 dollars).

3.10.2.4 Tourism and Recreation Based Economy at Hays on the Fort Belknap Reservation

Visitors to the Little Rocky Mountains generally contribute to business activity at Hays. Mostly, the effect is from visitors accessing the scenic, historic, and recreational values of Mission Canyon and of Little Peoples Creek. The main attractions are the resources found in Mission Canyon. Some of these are identified on the Official Montana Highway Map. The highlighting of these places on the map appears to generate some visitation by calling them to the attention of tourists looking for places of interest to visit.

Another potential attraction is the St. Paul's Mission Church in Hays. Resources in Mission Canyon include the Pow Wow grounds; the Sundance (or medicine) Lodge grounds; the natural bridge; the Kid Curry hideout; scenery, swimming, wading and fishing in Little Peoples Creek; informational signage; and picnic and campgrounds. Events that occur in Mission Canyon are the annual Pow Wow and Sundance during July, and a number of large family reunions each summer. Apart from this, general tourist and recreation visitors seek out the canyon for unscheduled use as the weather permits, which is primarily in the summer.

The two businesses in Hays that receive the primary benefit from Mission Canyon visitors are (1) a convenience store/cafe and (2) a convenience store/gas station. Visits to Hays and Mission Canyon have been promoted over the past several years by the owner of the second of these, and the qualitative analysis of this promotion effort indicates that tourism has increased as a result (Martin 1993). It may be noted that the observed increase has co-existed with the presence of the existing Zortman and Landusky mines. The level of visitation to Mission Canyon and its relationship to business activity in Hays is not recorded, and cannot be estimated from readily available information.

Spiritual activity of Native Americans also motivates visits to the Little Rocky Mountains. There is, or may be, a spiritual aspect to organized public events, such as the Pow Wow and Sundance, or organized private events, such as family reunions. Other spiritual activities are intensely personal. By outward appearances, the public activities have continued to be well-attended (Martin 1993). However, by some accounts, some persons intending to participate in the Sundance and or in personal spiritual activity may have been discouraged from participating by the presence of the existing Zortman and Landusky mines. However, information is not available to indicate if this response has occurred, how extensive it is, or if it has affected business activity in Hays.

3.10.2.5 Perceived Aesthetic Effects, Health Risks and Resultant Economic Effects Under Existing Conditions

A concern has been expressed during EIS scoping that recreational use of Little Peoples Creek in Mission Canyon may be a public health hazard. The concern is that chemicals entering the water and sediment from waste piles of past gold mining operations may be harmful if contacted or ingested, so warnings should be posted. If the creek were to be posted, this might discourage visitor recreation and affect related

business activity. The Federal Public Health Service (PHS) of the Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR) has assessed this concern. After reviewing the available data, ATSDR reported that the chemical concentrations do not pose a public health hazard; therefore, posting warning signs in the area was deemed unnecessary. ATSDR did recommend characterization of the chemical composition of mine waste which may be accessible to the public (Orloff 1992b; Muza 1993).

3.10.2.6 Population

The study area population in 1990 was about 11,900 (see Table 3.10-6), including Phillips County (5,136) and Blaine County (6,728). Communities within Phillips County with measured populations are Malta (2,340) and Dodson (137). Communities with measured populations in Blaine County are Chinook (1,512) and Harlem (882). The 1990 population of the Fort Belknap Indian Reservation was 2,508, including 189 in the Phillips County portion and 2,319 in the Blaine County portion of the reservation.

Population change within the study area has been consistent with local economic conditions. Total study area population declined by approximately 4 percent in 1990 from 1980, continuing a trend dating back several decades (SBS Economic Consulting 1990; Economic Consultants Northwest 1991). Phillips County population was 5,163 in 1990, down 4 percent from 1980. Blaine County population was 6,728 in 1990, down 4 percent from 1980. The decline in Blaine County population off the reservation was much larger than 4 percent because the growth in the reservation population offset the loss. For example, Chinook and Harlem, both off-reservation towns, declined about 9 percent and 14 percent, respectively, during this period.

The decline in population throughout most of the study area was due to people migrating from the area rather than into the area, largely because of minimal economic diversity and opportunity. This trend was heightened by recent declines in oil and gas activity and reductions in agricultural production and supporting businesses (SBS Economic Consulting 1990, Economic Consultants Northwest 1991). The exception to the overall trend was the Fort Belknap Indian Reservation, where reported population increased by approximately 28 percent from 1980 to 1990. In part, growth on the reservation is due to an increase in on-reservation residency of tribal enrollees because of increased availability of jobs and housing (Economic Consultants Northwest 1991).

Trends in population characteristics within the study area are consistent with the overall decline in population (see Table 3.10-7). The population in Phillips County aged during the decade and had a median age of about 34 in 1990 compared to about 30 in 1980. In 1990, median age in Phillips County was about the same as for the state of Montana as a whole. In contrast, Blaine County's population has tended to be younger than that of the state as a whole, largely due to the younger population on the Fort Belknap Indian Reservation. In 1990, median age was about 32 in Blaine County and about 23 on the Fort Belknap Indian Reservation. The two counties differ in racial composition, again due to the presence of the reservation in Blaine County. In 1990, Native Americans comprised about 7 percent of the population in Phillips County and about 40 percent of the population in Blaine County.

Phillips County is projected to grow very slowly, then to experience declines, and then to grow very slowly again for a net of almost no change in population over the next two decades (see Table 3.10-8). The projection assumes no major change in the current economic base of the county (SBS Economic Consulting 1990). Blaine County is projected to grow slowly for a total population increase of approximately 6 percent over the next two decades, an average annual growth rate of less than one-half of one percent. This projection assumes a continuation of past trends in employment in the county (Economic Consultants Northwest 1991).

3.10.2.7 Economic Effects of the Existing Zortman and Landusky Mines

The existing Zortman and Landusky mines have been in operation in Phillips County since 1979. At that time, no other economic activity approached agriculture in importance in Phillips County and in the Little Rocky Mountains area. Over time, the mines have added diversity to an economy hampered by limited natural resources and distance from population centers. Initially, the mines created about 30 to 40 direct jobs in Phillips County (DSL 1979a) a level that equated to about 1 percent of all the jobs available in the county in 1980. By 1985, there were about 190 direct jobs at the mines, consisting of about 90 jobs with Zortman Mining, Inc. and about 100 jobs with contract miner N.A. Degerstrom (DSL/BLM 1990). This 1985 direct employment level equated to about 7 percent of all jobs available in Phillips County at the time.

Currently employment at the mines averages about 200 workers. The mines also employ about 20 additional

TABLE 3.10-6
POPULATION IN THE STUDY AREA, 1970-90

	1970	1980	1990	% Change 1980-1990
Montana	694,409	786,690	799,065	1.6%
Study Area	12,113	12,366	11,891	-3.8%
Phillips County	5,386	5,367	5,163	-3.8%
Malta	2,195	2,367	2,340	-1.1%
Dodson	196	158	137	-13.3%
Other	2,995	2,842	2,686	-5.5%
Blaine County	6,727	6,999	6,728	-3.9%
Chinook	1,813	1,660	1,512	-8.9%
Harlem	1,094	1,023	882	-13.8%
Other	3,820	4,316	4,334	0.4%
Fort Belknap Indian Reservation	1,398	1,961	2,508	27.9%
Phillips County	NA	NA	189	NA
Blaine County	NA	NA	2,319	NA

Sources: (1) Census of Population 1990, (2) SBS Economic Consultants 1990, (3) Economic Consultants Northwest 1991.

TABLE 3.10-7
SELECTED STUDY AREA POPULATION CHARACTERISTICS
(1980 and 1990)

	Montana	Phillips County	Blaine County	Fort Belknap Reservation
Median Age				
1980	29.0	29.5	27.5	20.0
1990	33.9	34.0	31.6	23.1
Race, % White				
1980	92.8	92.4	NA	NA
1990	94.1	92.6	60.0	6.1
Race, % American Indian				
1980	4.7	6.7	NA	NA
1990	6.0	7.1	39.6	93.2

TABLE 3.10-8
POPULATION PROJECTIONS FOR PHILLIPS AND BLAINE COUNTIES, 1990 to 2010

	Montana	Phillips County	Blaine County
1990	799,065	5,163	6,728
1995	802,800	5,187	6,786
2000	798,700	5,160	6,862
2005	797,000	5,147	6,978
2010	799,000	5,160	7,122
Projected growth 1990-2010	0.0%	-0.1%	5.9%
Projected annual growth rate 1990-2010	0.0%	0.0%	0.3%

Sources (both tables): (1) Census of Population 1990, (2) SBS Economic Consulting 1990, (3) Economic Consultants Northwest 1991.

persons annually between April and October to perform reclamation and other seasonal work. Typically 15 of the seasonal workers are college students on a 3-month summer hire program. The students are children of mine employees. The remaining 5 seasonal workers are temporary employees hired locally for a period of five to six months. The temporary employees are eligible for unemployment when the season ends (Ryan 1994). Based on average employment levels, the mine's payroll currently is about $6.7 million per year, plus about $2.2 million in benefits (1993 dollars). Average earnings are about $44,000 per employee including benefits. The mine currently purchases about $23 million per year of goods and services used in operations (Eickerman 1993). Table 3.10-9 summarizes these data.

Two hundred jobs at the Zortman and Landusky mines represented about 50 percent of all mining jobs located in Phillips County and about 7 percent of all Phillips County jobs based on a comparison with general economic data from 1991. For the same period, the earnings of Landusky and Zortman employees represented 55 percent of earnings in the mining sector, and 17 percent of total earnings generated within Phillips County. (Since general economic data from 1991 are the latest available for Phillips County, dollar amounts of earnings were converted to 1991 equivalents for use in this comparison.)

As of October of 1993, mine employment was 223, about 89 percent of whom lived within the study area -- just under 77 percent (or 171 employees) lived in Phillips County; and just under 13 percent (or 28 employees) lived in Blaine County (Eickerman 1993). Forty-one employees of the existing mine are Native Americans, and all live within the study area. A breakdown of employee residency by study area community is presented in Table 3.10-10.

Of school-age children, 234 are associated with the mine workforce at this time and 212 attend schools within the study area (Eickerman 1993). A breakdown of school-age children by community also is presented in Table 3.10-10. The Zortman and Landusky mines' effect on total population within the study area is estimated to be about 460 persons in Phillips County communities, about 80 persons in Hays, and about 20 persons in other Blaine County communities. This estimate is based on household size factors from the 1990 census for Phillips and Blaine counties and the Fort Belknap Indian Reservation, as adjusted to account for specific household characteristics implied by information reported by the mine. See Table 3.10-10 for estimated mine-related population by community. Assuming about 89 percent of the mines' employees live in the study area, the mines' study area payroll was about $5.2 million in 1993.

A little less than 20 percent of total operating expenditures by the mine in 1993, or $4.6 million, were made within the study area, with about 99 percent of that amount spent in Phillips County. About 97 percent of expenditures within Phillips County occur in Malta, with the remainder spread among Zortman, Dodson and Saco (Thompson 1993). The mine purchases electrical power, fuels, and light vehicles from Phillips County suppliers. The small amounts expended in Blaine County are in Harlem, Chinook and Hays (Geyer and Erickson 1993).

A little more than 40 percent of total expenditures by the mine in 1993, or about $9.9 million, were made outside the study area but within other parts of the state of Montana. Of these expenditures, most were made in Billings (about $6.7 million) and Helena (about $1.2 million). Other Montana cities capturing more than $100,000 a year in mine expenditures are Butte, Bozeman, Missoula, Lewistown, and Havre. The remainder of the mines' expenditures in 1993, about $9 million or 40 percent, were made outside of Montana.

In 1993, $60,000 in operating expenditures represented purchases from Native American-owned businesses.

The earnings of local employees (less taxes) and business purchases from state and local suppliers are the Zortman and Landusky mines' direct contribution to the economy of the State of Montana and the study area. Additional business activity and employment is generated as these amounts circulate through the state and local economy.

Throughout the State of Montana, the 200 jobs, $6.7 million in payroll, and $23.0 million in operating expenditures by the Zortman and Landusky mines generated an additional 317 jobs and $6.4 million in earnings. These impacts included 87 jobs and $1.7 million in earnings, and within the study area consisting of Phillips and Blaine counties (see Table 3.10-9). The remaining economic impacts within the state occur mainly in the larger cities of Montana where equipment companies, chemical suppliers, and other vendors of goods and services utilized in the mining industry, are located. Examples of cities which capture a large share of the mine's purchases are Billings, Helena, Butte, Bozeman, and Missoula. Economic impacts also occur in communities that capture the remainder of the mine's Montana business spending and in communities outside of Phillips and Blaine counties where mine employees reside. (The impacts presented here were estimated

TABLE 3.10-9
ECONOMIC PROFILE FOR EXISTING ZORTMAN/LANDUSKY MINE:
DIRECT AND SECONDARY EFFECTS
October 1993
(expenditures in millions of 1993 dollars,
all values on average annual basis)

	Direct Effects	Secondary Effects (additional jobs and earnings)	
		Total In State of Montana (including Study Area)	In Study Area Only (Phillips and Blaine counties)
Employment	200	317	87
Labor Expenditures	$8.9	NA	NA
Payroll (excluding benefits)	$6.7	$6.4	$1.7
Benefits	$2.2	NA	NA
Operating Expenditures	$23.0	NA	NA

Sources: Eickerman 1993 for direct effects.
Estimates of secondary effects by Planning Information Corporation.

TABLE 3.10-10
DIRECT EMPLOYMENT, SCHOOL AGE CHILDREN, POPULATION BY COMMUNITY: ESTIMATED EFFECTS OF THE EXISTING LANDUSKY/ZORTMAN MINE
October 1993

	Employment			School-Age Children		Population (est)	
	Number	% Total	% Study Area	Number	% Study Area	Number	% Study Area
Total	223	100.0%		234			
Study Area	199	89.2%	100.0%	212	100.0%	556	100.0%
Phillips County	171	76.7%	85.9%	180	84.9%	457	82.2%
Dodson	10	4.5%	5.0%	11	5.2%	27	4.9%
Malta	108	48.4%	54.3%	146	68.9%	365	65.6%
Saco	4	1.8%	2.0%		0.0%	8	1.4%
Zortman	49	22.0%	24.6%	23	10.8%	57	10.3%
Blaine County	28	12.6%	14.1%	32	15.1%	99	17.8%
Chinook	2	0.9%	1.0%	6	2.8%	10	1.8%
Harlem	3	1.3%	1.5%	2	0.9%	8	1.4%
Hays	23	10.3%	11.6%	24	11.3%	81	14.6%
Other Counties	24	10.8%		22			
Fergus	21	9.4%		22			
Other	3	1.3%		0			

Source: Eickerman 1993 for employment and school-age children by community.
Population estimates by Planning Information Corporation.

using RIMS II multipliers for the State of Montana and procedures similar to those described in USDOC 1992. A multiplier is an economic ratio used to estimate the secondary economic repercussions of a direct economic impact.)

During the permitting process, economic conditions at the Zortman and Landusky mines have changed from when information was last collected in 1993. ZMI ran out of permitted ore, and layoffs occurred in two waves in December 1995 and January 1996. A total of 106 employees were laid off, a reduction of about 50 percent from the employment level of 1993. About 80 percent of the laid off employees were involved in mining and processing operations at the mines.

The socioeconomic effects of the layoffs at the Zortman and Landusky mines are still developing as of this analysis. To date, mine spending for payroll and business purchases has decreased in proportion to the decrease in employment. Household spending within the study area probably has been reduced, too, mainly because of reduced incomes to laid off employees remaining within the study area, since the maximum unemployment compensation in Montana is less than one-third the average ZMI wage and the wage scale of other local employers is typically lower than ZMI's. The economic repercussions of reduced ZMI and household spending would be felt throughout Phillips and Blaine counties and elsewhere in Montana where mine suppliers are located.

The main effect of the layoffs on the community has been an increase in unemployment. Although a few laid off employees have obtained other jobs, most have remained unemployed and have not relocated for the time being. ZMI is paying for medical insurance for laid off employees and will continue to do so through June 1996. A dozen or more persons laid off at the Zortman and Landusky mines have taken jobs at a Pegasus Gold Inc. mine in Nevada; about half the persons in this group have moved their families to Nevada.

3.10.3 Facilities and Services

This section describes the availability and specific limitations of facilities and services within the study area in Phillips and Blaine counties and on the Fort Belknap Indian Reservation. Facilities and services described are law enforcement, fire protection, solid waste, water and wastewater, utilities, planning, education, housing, medical and long-term care, and emergency response. The description focuses on communities which have the most potential to be affected by population change brought on by the proposed action and alternatives. The identification of potentially affected areas is based on where current Landusky and Zortman mine employees live. Communities considered in this section include those within the study area where three or more current mine employees reside (see Table 3.10-10). Therefore, Harlem (Blaine County) is considered, but Chinook (Blaine County) is not. Facilities and services available in unincorporated areas of the county also are described. In the counties (excluding the reservation), most services are provided by public agencies such as county and city government, school districts, and special districts. These agencies rely almost entirely on local public revenues. The fire and ambulance services are all staffed by volunteers. On the reservation, law enforcement, hospital, medical, and ambulance services are provided by the BIA with federal funds.

3.10.3.1 <u>Phillips County</u>

Table 3.10-11 summarizes the facilities and services available in unincorporated Phillips County and in the communities of Malta, Zortman, and Dodson. In general, facilities and services, though limited, are adequate and within the range of expectation for a sparsely populated county lacking a community of more than 2,500 and far from other population centers. Limitations observed are no juvenile detention facility, difficulty responding to fires in rural areas in winter, a space shortage at the elementary school in Malta, a single hospital with no intensive care or surgical services, and no local air ambulance transport.

3.10.3.2 <u>Blaine County</u>

Table 3.10-12 summarizes the facilities and services available in unincorporated Blaine County and in the communities of Harlem and the Fort Belknap Indian Reservation, including Hays. In Blaine County (excluding the reservation), facilities and services are also limited though adequate for a sparsely-populated, rural county. Limitations noted in Blaine County (reservation excluded) include understaffing of the sheriff's department, present and historic lack of elementary school capacity at Harlem, no hospital, one long-term care facility (in Chinook) operating at capacity, past space shortages at the Harlem elementary school, understaffing of the Chinook ambulance station, and the existence of remote areas of the county where it may be quicker to call the air ambulance out of Great Falls than the local ambulance. Some limitations, such as the lack of a county hospital, are offset by proximity to Havre (Hill County).

TABLE 3.10-11
FACILITIES AND SERVICES IN PHILLIPS COUNTY

	Unincorporated Phillips County	City of Malta	Zortman	Landusky	Dodson
Law Enforcement	Phillips County Sheriff's Office in Malta. *Juvenile detainees sent to Billings.*	Phillips County Sheriff's Office under contract to city.	See unincorporated Phillips County.	See unincorporated Phillips County.	See unincorporated Phillips County.
Fire Protection	Volunteer fire district with stations in Malta, Zortman. Wildland fire trucks in Malta, Zortman, Dodson, Loring. *Rural response difficult, especially in winter.*	Volunteer fire station.	Volunteer fire district station.	See unincorporated Phillips County.	See unincorporated Phillips County.
Solid Waste	County-wide sanitation district. *Sites and collection points NA.*	County-wide sanitation district. *Sites and collection points NA.*	County-wide sanitation district. *Sites and collection points NA.*	County-wide sanitation district. *Sites and collection points NA.*	County-wide sanitation district. *Sites and collection points NA.*
Water and Wastewater	Well and septic.	City operated. *Old water mains. Wastewater at 80% capacity.*	Public water system. Septic.	Private water wells and septic tanks.	See unincorporated Phillips County.
Utilities	Natural gas, electricity, telephone generally available.	Natural gas, electricity, telephone.	See unincorporated Phillips County.	See unincorporated Phillips County.	See unincorporated Phillips County.
Planning	Building permits. 1987 master plan.	Building permits. Zoning.	See unincorporated Phillips County.	See unincorporated Phillips County.	See unincorporated Phillips County.

TABLE 3.10-11 - FACILITIES AND SERVICES (PHILLIPS COUNTY) (Continued)

	Unincorporated Phillips County	City of Malta	Zortman	Landusky	Dodson
Education	Public elementary in Malta, Dodson, Landusky, Saco, Second Creek and Whitewater. Public secondary in Malta, Dodson, Saco and Whitewater. *See limitations noted under other locations.*	Public elementary and secondary. Parochial elementary. *As of 1990, no public K-6 capacity to absorb additional pupils without adversely affecting accreditation.*	Public elementary. High school in Malta. *Two-classroom building. One teacher*	Public elementary. High school in Malta or Dodson.	Public elementary and secondary. *All grades in one 13-classroom building.*
Housing	New construction permitted with building permit and adequate sewage disposal. Change of use, survey, soil and drainage reports may be required. *Availability NA.*	Housing generally available for sale and rent. New construction permitted. Mobile homes permitted in designated zones.	See unincorporated Phillips County. *Availability NA.*	See unincorporated Phillips County. *Availability NA.*	See unincorporated Phillips County. *Limited availability of housing, lots.*
Medical	See Malta.	Hospital, medical clinic, home nursing service. *No intensive care or operating room services. Emergency medical service sometimes on call.* Alcohol and drug counseling.	See Malta.	See Malta.	See Malta.

TABLE 3.10-11 - FACILITIES AND SERVICES (PHILLIPS COUNTY) (Concluded)

	Unincorporated Phillips County	City of Malta	Zortman	Landusky	Dodson
Long-Term Care	See Malta.	Personal care home. Skilled nursing home. Retirement apartments.	See Malta.	See Malta.	See Malta.
Emergency Response	Volunteer ambulance district stations in Saco, Whitewater. *Emergency call may be long distance.* *No Jaws-of-Life.* *No local emergency air transport.*	Volunteer ambulance district station. *No Jaws-of-Life.* *No local emergency air transport.*	Volunteer ambulance district station. *Emergency call may be long distance.* *No Jaws-of-Life.* *No local emergency air transport.*	See unincorporated Phillips County.	See unincorporated Phillips County.

Source: SBS Economic Consulting 1990.

Notes: Table identifies services available and describes *any known limitations (in Italics)*
"NA" in table means this location was not addressed in the source document and, therefore, information is currently not available.

TABLE 3.10-12
FACILITIES AND SERVICES IN BLAINE COUNTY

	Unincorporated Blaine County	Harlem	Fort Belknap Indian Reservation and Hays
Law Enforcement	Blaine County Sheriff's Department in Chinook. *More patrol officers, one corrections officer required for current workload. Harlem has working relationship with BIA on pursuit of offenders.*	Harlem Police Department *Harlem police have working relationship with BIA police on pursuit of offenders.*	BIA Police Department in Fort Belknap Agency. *Needed jail renovation is pending.*
Fire Protection	Volunteer fire service in Chinook, Harlem, Fort Belknap Reservation. Brush-fire trucks located on farms in rural areas.	Volunteer fire service in Harlem.	Fort Belknap Community Fire Department for structure fires. Volunteers in Fort Belknap Agency, Hays, Lodgepole. BIA Fire Department for wild fires. *Development of Hays fire hall pending.*
Solid Waste	Consolidated refuse district has container sites in Harlem, Chinook.	Consolidated refuse district container site.	Open pit landfills. *Fort Belknap Community has joined consolidated refuse district. Landfill closure and new collection method pending.*
Water and Wastewater	Well and septic.	Harlem municipal systems.	Hays community water supply serves most homes. Others on wells. Hays wastewater system serves some homes. Others on septic. *1992 samples from several private wells in Hays contained levels in excess of EPA Secondary Maximum Contaminant Levels (SCML) of naturally occurring inorganic chemicals often found in groundwater throughout the area. See Section 3.10.3.2.*

TABLE 3.10-12 - FACILITIES AND SERVICES (BLAINE COUNTY) (Continued)

	Unincorporated Blaine County	Harlem	Fort Belknap Indian Reservation and Hays
Utilities	Natural gas, electricity, telephone generally available.	Natural gas, electricity, telephone.	Electricity, telephone available in Hays. *Wood and propane are used as alternatives to electricity for home heating.*
Planning	*Comprehensive plan pending.*	Zoning and regulation for residential, mobile home, business location.	NA
Education	Public elementary and secondary schools in Chinook and Harlem.	Public elementary and secondary schools in Harlem. *In 1991 overcrowding existed K-6, but was accommodated through use of excess capacity 7-12.*	Public elementary at Lodgepole and secondary at Hays. Parochial elementary at Hays. *In 1991 overcrowding was accommodated by housing K-5 at Lodgepole and 6-12 at Hays.*
Housing	Home construction permitted under Montana state subdivision and public health. *No county building code.* *Housing availability NA.*	Some houses available for sale. Some apartments available for rent. New home construction permitted. Mobile homes permitted in designated zones. *Mobile home space availability NA.*	*On-reservation program housing restricted to American Indians.* *Non-program housing availability NA.*
Medical	Medical clinic, mental health counseling, home health nurse in Chinook. *Hospitals in Havre and Malta.*	See unincorporated Blaine County.	Indian Health Service (IHS) hospital, medical clinic, chemical dependency treatment in Fort Belknap Agency. Satellite medical clinic in Hays. *On-reservation services restricted to American Indians.* *New hospital construction pending.*
Long-Term Care	Nursing home in Chinook. *Operating at capacity or more.*	Nursing home.	*No on-reservation long-term care facilities.*

TABLE 3.10-12 - FACILITIES AND SERVICES (BLAINE COUNTY) (Concluded)

	Unincorporated Blaine County	Harlem	Fort Belknap Indian Reservation and Hays
Emergency Response	Volunteer ambulance service stations at Chinook, Harlem, Turner. *Understaffed.* *In remote areas air ambulance from Great Falls may be quicker.*	Volunteer ambulance service.	IHS ambulance service at Fort Belknap Agency, Hays.

Source: SBS Economic Consulting 1990.

Notes: Table identifies services available and describes any *any known limitations (in Italic)*
"NA" in table means this location was not addressed in the source document, and therefore, information is currently not available.

Many facilities and services on Fort Belknap Indian Reservation are provided by either the Fort Belknap Indian Community or the BIA. Observed limitations include needs for jail renovation, a fire hall in Hays, a new solid waste disposal system, alternatives to electricity for home heating, relief from elementary school overcrowding in Hays, and retention and replacement of the aging Indian Health Service (IHS) hospital.

3.10.4 Local Government Fiscal Conditions

Fiscal conditions are presented in the following subsections for Phillips County, the City of Malta, Malta High School, Malta Elementary School, Dodson High School, and Landusky Elementary School. These jurisdictions derive revenues directly from the existing Zortman and Landusky mines. Fiscal conditions are also presented for Blaine County and the Fort Belknap Indian Reservation. Finally, the current direct contribution of the existing Landusky and Zortman mines to local taxing jurisdictions in Phillips County is estimated.

3.10.4.1 Phillips County

Table 3.10-13 presents total taxable value and total property tax levies in Phillips County through the present. Total taxable value was about $20.3 million in 1993 and is estimated to be about $19.8 million in 1994. The estimated 1994 level is a decrease of 45 percent from 1990 and represents a continuation of a declining trend since 1985. The total property tax levy was 43.63 mills in 1993 and is estimated to be 47.76 mills in 1994, an increase of about 65 percent since 1990. Components of the current tax base are presented in Table 3.10-14. Centrally assessed property (including pipelines, gas companies, railroads and net proceeds from oil and gas valuation) is the largest component (32 percent), followed by personal property (27 percent), agricultural property (18 percent), and improved real property (13 percent).

In fiscal year (FY) 1993, Phillips County reported budgeted revenues of about $6 million, up 13 percent from FY 1990 (Table 3.10-15). As a share of total revenue, property taxes decreased to 14.2 percent in FY 1993, down from a 19 percent share in FY 1990, a decrease in property tax revenue of about 17 percent between FY 1990 and FY 1993. The category of "Other Revenues," the largest share of the county's revenue base, doubled between FY 1990 and FY 1993. This was due to the need to develop other revenue sources in order to offset a decrease in property tax revenues. The decline in property tax revenues reflected, in part, a decline of more than 40 percent in taxable value during the same period. In the same period, budgeted expenditures went from $4.5 million to $ 3.5 million, a 21 percent decrease. Nearly 40 percent of all expenditures went towards public works and highway construction and maintenance. The next largest category is general government (23 percent), which covers financial and legislative services and facilities administration. More than 16 percent of expenditures went to cover police, fire, and judicial responsibilities.

3.10.4.2 City of Malta

Total taxable value for the City of Malta (Table 3.10-15) was $2,183,957 in FY 1993, down about 3 percent from in FY 1990. The City of Malta general fund covers the functions of public safety, general government, and public works. Water, sewer, and refuse are handled through enterprise funds. Total budgeted resources were $837,212 in FY 1993, up 14 percent from FY 1990. Revenues from property taxes were almost unchanged in FY 1993 compared to FY 1990 and other taxes increased about 5 percent. Property tax revenues were a 30 percent share of total resources in FY 1993, down from 34 percent in FY 1990. Between FY 1990 and FY 1993, total budgeted general fund expenditures increased from $445,270 to $452,713 (up about 2 percent). About 50 percent of general fund expenditures went to public safety, followed by general government (32 percent) and recreation and culture (18 percent).

3.10.4.3 Malta High School District

Fiscal conditions of the Malta High School District are presented in Table 3.10-16. Malta High School had an average number of students belonging (ANB) of 222 in FY 1993, up 2.3 percent from 217 in FY 1990. In FY 1994, ANB is expected to be 231, up about 4 percent (Baden 1993). In FY 1993, Malta High School operated on a budget of about $1.2 million (excluding comprehensive insurance), up about 15 percent from about $1.1 million in 1990. About 85 percent of the FY 1993 budget was in the general fund. In FY 1993, property tax revenues financed about 15 percent of total budgeted expenditures, down from 32 percent in FY 1990. Property tax revenues were about $178,000 in FY 1993, down about 48 percent from FY 1990. The decline in property tax revenues was offset by other forms of state and local revenue, such as state and county education equalization funds. Taxable value in the Malta High School District was $9.2 million in FY

TABLE 3.10-13
PHILLIPS COUNTY TAXABLE VALUE AND PROPERTY TAX LEVIES
(current dollars)

Fiscal Year	Taxable Value	Total Levy
1980	$19,152,182	62.55
1985	39,347,917	32.55
1990	36,275,397	28.88
1993	20,295,327	43.63
1994	19,865,693	47.76

Source: Barnard 1993, Phillips County Assessor, Phillips County budget documents.

TABLE 3.10-14
COMPONENTS OF PHILLIPS COUNTY TAXABLE VALUE, FY 1994
(estimated current dollars)

Property Type	Market Value	Taxable Value
Agricultural	$12,249,426	$3,674,827
Non-Agricultural	13,719,289	474,320
All Improvements	73,457,273	2,613,888
Total Allocations	64,253,862	6,391,345
Gross Proceeds	41,408,877	1,242,266
Personal Property	73,930,287	5,465,159
Intra-County Co-Op	129,604	3,888
Total	$279,148,618	$19,865,693

Source: Barnard 1993, Phillips County Assessor.

TABLE 3.10-15
SELECTED GENERAL PURPOSE GOVERNMENT IN PHILLIPS COUNTY, BUDGETED REVENUES AND EXPENDITURES, FY 1990-93
(current dollars)

	Phillips County			City of Malta		
	FY	FY	% Change	FY	FY	% Change
	1990	1993	FY '90-93	1990	1993	FY '90-93
Revenues[1]						
Property Taxes	$1,033,913	$860,494	-16.8%	$247,159	$247,177	0.0%
Other Revenues	1,335,598	2,714,390	103.2%	389,387	406,718	4.5%
Cash less Liability	2,975,054	2,466,916	-17.1%	208,250	183,317	-12.0%
Total Resources	$5,344,565	$6,041,800	13.0%	$732,030	$837,212	14.4%
Expenditures[1]						
General Govt.	$815,710	$803,862	-1.5%	$145,162	$144,1775	-0.7%
Public Safety	553,040	572,185	3.5%	231,297	224,540	-2.9%
Social/Health	469,539	466,246	-0.7%	1,050	400	-61.9%
Rec. Culture	153,700	120,935	-21.3%	64,180	79,647	24.1%
Public Works	2,080,338	1,496,831	-28.0%	3,581	4,000	12.0%
Misc.	410,655	63,630	-84.5%	NA	NA	NA
Total	$4,482,982	$3,523,689	-21.4%	$445,270	$452,713	1.7%

[1] City of Malta data exclude enterprise activity expenses and revenues.

Source: Phillips County budget documents, City of Malta budget documents.

TABLE 3.10-16
SELECTED SCHOOL DISTRICTS IN PHILLIPS COUNTY, BUDGETED REVENUES AND EXPENDITURES, FY 1990-93
(current dollars)

	Malta Elementary School District[1]			Malta High School District			Landusky Elementary School District			Dodson High School District		
	FY 1990	FY 1993	% Change 90-93	FY 1990	FY 1993	% Change 90-93	FY 1990	FY 1993	% Change 90-93	FY 1990	FY 1993	% Change 90-93
Property Tax Revenues												
General	$280,487	$354,207	26.3%	$324,711	$155,789	-52.0%	$9,782	$7,966	-18.6%	$143,662	$97,191	-32.3%
Mills	37.01	41.69	12.6%	39.56	16.81	-57.5%	3.04	3.00	-1.3%	29.82	23.00	-22.9%
Transportation	$60,194	$24,722	-58.9%	$14,032	$20,460	45.8%	$1,300	$0	-100.0%	$26,156	$26,960	3.1%
Mills	7.95	2.96	-62.8%	1.71	2.21	29.2%	0.41	0	-100.0%	5.43	6.38	17.5%
Debt Service	$250	$961	284.4%	$478	$1,998	318.0%	$0	$0	0.0%	$33,056	$37,101	12.2%
Mills	0.04	0.12	200.0%	0.06	0.22	266.7%	0.00	0.00	0.0%	6.86	8.78	28.0%
Tuition	$19,572	$1,686	-91.4%	$0	$0	0.0%	$0	$0	0.0%	$0	$0	0.0%
Mills	2.59	0.20	-92.3%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
Adult Education	$0	$0	0.0%	$0	$0	0.0%	$0	$0	0.0%	$0	$1,997	
Mills	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.48	
Total Revenues	$360,503	$381,576	5.8%	$339,221	$178,247	-47.5%	$11,082	$7,966	-28.1%	$202,874	$163,249	-19.5%
Total Mills[2]	47.59	44.97	-5.5%	41.33	19.24	-53.4%	3.45	3.00	-13.0%	42.11	38.64	-8.2%
Taxable Value	$7,579,493	$8,351,331	10.2%	$8,209,623	$9,254,987	12.7%	$3,226,113	$2,654,595	-17.7%	$4,818,804	$4,225,705	-12.3%

TABLE 3-10.16 - SELECT SCHOOL DISTRICT BUDGETED REVENUES AND EXPENDITURES (PHILLIPS COUNTY) (Concluded)

	Malta Elementary School District[1]			Malta High School District			Landusky Elementary School District			Dodson High School District		
	FY 1990	FY 1993	% Change 90-93	FY 1990	FY 1993	% Change 90-93	FY 1990	FY 1993	% Change 90-93	FY 1990	FY 1993	% Change 90-93
Expenditures by Fund												
General	$1,275,982	$1,607,805	26.0%	$917,069	$1,049,894	14.5%	$29,235	$33,315	14.0%	$429,684	$483,336	12.5%
Transportation	112,650	116,000	3.0%	59,968	67,000	11.7%	4,742	2,847	-40.0%	61,573	64,083	4.1%
Retirement	169,500	190,135	12.2%	93,500	109,555	17.2%	2,629	3,050	16.0%	38,600	56,000	45.1%
Debt Service	900	1,500	66.7%	900	2,500	177.8%	0	0	0.0%	60,670	62,992	3.8%
Tuition	20,707	2,250	-89.1%	0	0	0.0%	0	0	0.0%	0	0	0.0%
Adult Education	0	0	0.0%	0	0	0.0%	0	0	0.0%	1,936	4,800	147.9%
Total Budget[2]	$1,579,739	$1,917,690	21.4%	$1,071,437	$1,228,949	14.7%	$36,606	$39,212	7.1%	$592,463	$671,211	13.3%
ANB	495	463	-6.5%	217	222	2.3%	13	8	-38.5%	41	50	22.0%

Source: Final Budget Report, Montana Office of Public Instruction 1993.

[1] The Malta Elementary School District includes the Zortman Elementary School.
[2] The total mill levy for each district excludes comprehensive insurance.

Notes: ANB - Average Number Belonging

1993, up 13 percent from $8.2 million in FY 1990. In FY 1994 taxable value is expected to be about $8.4 million, down about 10 percent (Baden 1993). The total levy for the district was 19.24 mills in FY 1993, down by about 50 percent from 41.33 in FY 1990. The mill levy is expected to increase to 33.86 mills in FY 1994. Similar to other school districts in Phillips County, the Malta High School District receives a large share of total revenues from ad valorem taxes directly associated with the existing Zortman and Landusky mines.

3.10.4.4 Malta Elementary School District (including Zortman Elementary)

Fiscal conditions of the Malta Elementary School District, which includes the Zortman Elementary School, are presented in Table 3.10-16. The district maintains schools in Malta, Tallow Creek, Loring, and Zortman. ANB for the district was 463 in FY 1993, down 6.5 percent from 495 in FY 1990. ANB in FY 1994 is expected to decrease by 2 (Baden 1993). Malta Elementary School operated on a budget of $1.9 million in FY 1993, up 21 percent from $1.57 million in FY 1990. About 84 percent of FY 1993 expenditures were in the general fund. Property tax revenues were about 20 percent of expenditures in FY 1993, down about 6 percent from 22 percent in FY 1990. Total revenue from property taxes was $381,576 in FY 1993, up about 6 percent from $360,503 in FY 1990. Taxable value was $8.3 million in FY 1993, up about 10 percent from $7.5 million in FY 1990. In FY 1994, taxable value is expected to be about $7.5 million, down about 11 percent. The total property tax levy was 44.97 mills in FY 1993, down from 47.59 mills in FY 1990. The total levy for FY 1994 is expected to be 66.93 mills, up 48 percent (Baden 1993).

3.10.4.5 Landusky Elementary School District

Fiscal conditions of the Landusky Elementary School District are presented in Table 3.10-16. ANB for the district was 8 in FY 1993, down from 13 in FY 1990. Because of its small size, ANB for the Landusky Elementary School is hard to predict. Local officials are expecting an ANB of 10 in FY 1994 (Williams 1993). Landusky Elementary School operated on a budget of $39,212 in FY 1993, up from $36,606 in FY 1990. About 85 percent of FY 1993 expenditures were in the general fund. Property tax revenues were 20 percent of expenditures in FY 1993, down from 42 percent in FY 1990. Total property tax revenues were $7,966 in FY 1993, down from $11,082 in FY 1990. Taxable value was $2.6 million in FY 1993, down about 18 percent from $3.2 million in FY 1990. The total property tax levy was 3.00 mills in FY 1993, down from 3.45 mills in FY 1990. The total levy for FY 1994 is expected to be 28.09 mills. The additional 22.7 mills would finance the cost of a new multi-purpose building (Williams 1993).

3.10.4.6 Dodson High School District

Fiscal conditions of the Dodson High School District are presented in Table 3.10-16. The district operates within a single building and serves grades K-12. ANB for the district was 50 in FY 1993, up from 41 in FY 1990 (+22 percent). Dodson High School operated on a budget of $671,211 in FY 1993, up from $592,463 in FY 1990 (+13 percent). About 72 percent of FY 1993 expenditures were in the general fund. Property tax revenues were about 24 percent of expenditures in FY 1993, down from 34 percent in FY 1990. Total revenue from property taxes was $163,249 in FY 1993, down from $202,874 in FY 1990 (-19.5 percent). Taxable value was about $4.2 million in FY 1993, down from $4.8 million in FY 1990 (-12.3 percent). The total property tax levy was 38.64 mills in FY 1993, down from 42.11 mills in FY 1990 (-8.2 percent). The total levy for FY 1994 is expected to be 38.40 mills, which represents a slight decrease (Baden 1993).

3.10.4.7 Blaine County

Total Blaine County taxable value was approximately $13.8 million in FY 1993, down 52 percent from FY 1990. The property tax levy was 74.19 mills in FY 1993, up more than 13 percent from 65.29 mills in FY 1990. Budgeted property taxes for Blaine County government were about $1 million in FY 1993, down 45 percent from FY 1990. Property taxes were about 28 percent the total FY 1993 budgeted expenditures, down from a 39 percent share in FY 1990. Total budgeted expenditures were $3.6 million in FY 1993, down 24 percent from $47 million in FY 1990. Twenty-eight percent of expenditures were budgeted for public works and highway construction and maintenance followed by general government (22 percent).

3.10.4.8 Fort Belknap Agency

The FY 1993 budget for the Fort Belknap Agency was $7.3 million. About $2.7 million (38 percent) was for tribal priority allocations used to support on-going programs of the Fort Belknap Indian Community. Tribal priority allocation has increased substantially over

the past three or four years. Other major funding categories were $1.8 million for recurring programs which include human services, community development, and resource management; $1.3 million for resource management, including project construction and survey design; and $144,900 for fire management and pre-suppression (Boxer 1993).

3.10.4.9 Hays-Lodgepole School District

The Hays-Lodgepole School District is a K-12 district which operates schools on the Fort Belknap Indian Reservation within Blaine County. The Hays-Lodgepole School District houses the lower grades in facilities at Hays and the upper grades at facilities in Lodgepole. In FY 1993, virtually all of the district's revenues were due to Federal and state entitlement programs. The largest of these entitlements was Federal Impact Aid, a program of direct payments to school districts that educate students who live on Federal land, including Indian land. Most of the rest of the district's revenues are from two Montana school finance programs: the state-county foundation program and the guaranteed tax base program. Local ad valorem property taxes are an extremely small part of the revenue base of the Hays-Lodgepole School District. In any case, no facilities or property belonging to the Zortman and Landusky mines are located within the taxing jurisdiction of this school district (Anderson 1994).

3.10.4.10 Fiscal Contribution of Existing Zortman and Landusky Mines

Taxes directly levied upon the existing Zortman and Landusky mines benefit the State and a number of local taxing jurisdictions. All of the local jurisdictions are within Phillips County. Taxing jurisdictions within Blaine County do not levy taxes directly on the existing mine because it is located entirely within Phillips County (Barnard 1994). Neither is there a direct fiscal contribution by the mine to the Fort Belknap Indian Reservation in the form of rents or royalties because no mine property is located on any reservation ground (Ryan 1994).

The existing Zortman and Landusky mines pay ad valorem property taxes on the taxable value of real and personal property and the taxable value of the operation's net proceeds (the value of the mineral produced less certain costs, which is how mineral-bearing property is assessed in the State of Montana). For FY 1994, ZMI's operations had an estimated taxable value of about $4.0 million, or about 20 percent of the total taxable value of property within Phillips County. (Barnard 1993 or 1994?). Taxable value is established by Montana statute as a percentage of market value for each type of property or minerals.

Property taxes for use by general purpose governments are levied on the existing Zortman and Landusky mines by Phillips County government and on some residences owned by ZMI by the City of Malta. Property taxes for public education are assessed at several different jurisdictional levels. The State of Montana levies property taxes for the state university system and for programs that support local public schools. State levies for local school support are pooled and redistributed by formula. Therefore, they may indirectly benefit schools within Phillips County through the State school funding equalization programs.

Other State mandated public education property taxes are assessed at the county level for support of public schools within the county and for school transportation and personnel retirement programs. These funds are pooled at the county level and redistributed by formula to schools within the county.

Still other public education property taxes are levied directly by the local school districts where ZMI property is located. These are the Malta Elementary School District, which operates elementary schools in Malta and Zortman; the Malta High School District, which serves high school students from Malta, Zortman, and other communities in Phillips County; the Landusky Elementary School District, which operates the Landusky Elementary School; and the Dodson High School District, which serves high school students from Landusky, Dodson and other communities in Phillips County.

The existing mine is also assessed the metal mines license tax on the gross value of shipped product in excess of $250,000 (Hines 1993). Twenty-five percent of that tax is allocated directly to Phillips County; the remaining 75 percent goes to the State of Montana. At least 40 percent of the county allocation goes to the County Hard-Rock Mine Trust Reserve Account. That fund had an FY 1993 balance of approximately $1.1 million. The remainder is distributed as follows: (1) one-third to the county's Metal Mines Tax Reserve Account, (2) one-third to the affected high school districts of Malta and Dodson, and (3) one-third to the affected elementary school districts in Landusky and Malta. Funds allocated to the County are earmarked for impact mitigation, planning, and economic

development. School districts may use their allocations for general purposes.

The total direct tax contribution for FY 1994 of the existing Zortman and Landusky mines is estimated as about $1.7 million (see Table 3.10-17). The distribution of these amounts may be summarized as follows: about $522,000 accrued to the general fund and other funds of the State of Montana and about $473,600 accrued to the State- and County-level public school funding programs. Some of the latter benefit schools within Phillips County through allocations from these school funding programs. The remainder of about $665,500 accrued directly to a variety of taxing jurisdictions in Phillips County for local government services and public education. These amounts were derived from a combination of property taxes and distributions of the metal mines license tax. The estimates assume FY 1994 mineral production, gross mineral value, and property tax mill levies.

As a measure of their importance, the amounts may also be expressed as a percent of current budgeted revenues for selected jurisdictions: Landusky Elementary School District, $95,600 or 81 percent of budgeted revenues; Dodson High School District, $124,600 or 20 percent; Phillips County, $289,000 or 9 percent; Malta Elementary School, $99,400 or 5 percent; and Malta High School, $55,800 or 5 percent. The City of Malta received $1,100, less than one percent of budgeted revenues.

As noted above, the State allocates 25 percent of metal mines license tax collections from ZMI to Phillips County and requires the County to save at least 40 percent of its allocation in the Hard-Rock Mine Trust Reserve Account (Montana Code Annotated 15-37-117). The purpose of this allocation is to have mining operations contribute to the mitigation of the eventual economic and fiscal impacts of closure. Money in the County's Hard-Rock Mine Trust Reserve Account is to be available for local use at mine closure as defined by statute. At that time, at least one-third of the balance in the account must be allocated to local schools for use in mitigating their fiscal impacts. The remainder may be used by the County for debt repayment, property tax relief, economic development, industry recruitment, job development incentive programs, and grants and loans to other impacted local jurisdictions.

The existing Zortman and Landusky mines also pay other state taxes which indirectly benefit Phillips and Blaine counties. These taxes include corporate income taxes and payroll taxes. A share of these tax revenues are allocated to local governments on a per capita or other proportional basis determined by state statute. The contribution to state and local jurisdictions has not been estimated in this analysis.

Although 13 percent of the mine work force (or about 28 workers) live in Blaine County, note that Blaine County receives no tax revenue from the mines. This situation has not had a fiscal impact on Blaine County since the mine opened in 1979 according to a local official. This is because most mine workers who reside in Blaine County were local hires from the Hays area on the Fort Belknap Indian Reservation. These workers lived in the area before the mines reopened, and probably would continue to live there if the mines closed (Benson 1994).

3.10.5 Social Conditions

In this section, objective indicators of social well-being (that is, selected measures of population characteristics) are presented for Phillips County and Blaine County, including the Fort Belknap Indian Community centered on the Fort Belknap Indian Reservation. Then, an overview of social values (or other aspects of the population not captured in reports on employment or income) is presented for each county and for the Fort Belknap Indian Community. Finally, the potentially affected communities are discussed in terms of their ability to adapt to change.

3.10.5.1 Social Well-Being in Phillips County

Indicators of social well-being in Phillips County (Table 3.10-18) present a mixed picture, suggesting the positive and negative factors associated with rural areas. The county lacks some basic services: the number of physicians per 100,000 population is much lower than state and national averages, educational attainment is lower, and the proportion of housing lacking some or all plumbing (an indicator of housing quality) is higher than state averages. Per capita income (1991) is lower than the state and nation, and median family income is lower than for the state. Out-migration from 1980 to 1987 was somewhat higher than for the state as a whole. On the other hand, the percent of families below the poverty line (Economic Consultants Northwest 1991) was slightly lower than state averages, the unemployment rate (1991) was lower than state averages, and the crime rate (1991) was lower than state averages. Other positive factors are the sparse population (which contributes to the low crime rate), plentiful opportunities for recreation, and a predominance of family ranching operations.

TABLE 3.10-17
FISCAL CONTRIBUTION OF THE EXISTING ZORTMAN/LANDUSKY MINE, FY 1994
(estimated)

	Ad Valorem Property Tax[1]	Metal Mines License Tax	Total	%	% Total Budgeted Revenues
State of Montana[2]	$23,800	$498,200	$522,000	31	NA
State/County School Funding[3]	473,600	NA	473,600	29	NA
Phillips County[4]	189,400	99,600	289,000	17	9
City of Malta[4]	1,100	NA	1,100	<1	<1
Malta Elementary School District[5]	82,800	16,600	99,400	6	5
Malta High School District[5]	39,200	16,600	55,800	3	5
Landusky Elementary School District[5]	79,000	16,600	95,600	6	81
Dodson High School District[5]	108,000	16,600	124,600	8	20
Total	$996,900	$664,200	$1,661,100	100	NA

[1] Includes gross proceeds tax, plus tax on real and personal property.
[2] Property tax accrues to university system. Metal mines license tax accrues to general fund and Resource Indemnity Trust Fund.
[3] Countywide education levies accrue to state and county equalization programs, county transportation, and county elementary and high school retirement.
[4] Includes only revenues attributable to taxes paid directly by ZMI. Excludes taxes, fees, charges for service, etc. paid by resident mine employee households.
[5] Property taxes include only those directly levied by the school district.

NA - Calculation of this statistic is not appropriate for this level.

Source: Phillips County Assessor, Phillips County Clerk.
Estimates by Planning Information Corporation.

TABLE 3.10-18
OBJECTIVE INDICATORS OF SOCIAL WELL-BEING

	Phillips County	Blaine County	FBIR[1]	Montana	United States
Physicians per 100,000 population (non-federal) 1985[2]	18	28	8	136	197
Education level-percent population completing high school 1990[3]	74.1%	70.4%	67.4%	81.0%	75.2%
Percent housing lacking some or all plumbing 1990[3]	8.0%	2.2%	3.2%	1.9%	1.1%
Per capita personal income 1991[4]	$13,680	$10,534	NA	$15,680	$19,091
Median family income 1989[3]	$26,862	$21,347	$14,583	$28,044	$35,225
Percent families below the poverty level 1989[3]	11.5%	23.2%	40.6%	12.0%	10.0%
Percent population in the working age group 18-64 yrs old[5]	54.4%	53.6%	50.3%	58.9%	61.8%
Percent net migration 1980-1987[6]	-4.1%	-9.8%	NA	-3.7%	NA
Unemployment rate 1989[7]	4.9%	8.5%	75.3%	5.9%	NA
Major crime rate per 1,000 population 1989[7]	24.0	8.8	NA	38.1	NA

[1] FBIR - Fort Belknap Indian Reservation (part within Phillips County and part within Blaine County, includes communities of Hays and Lodgepole)
[2] Source: City and County Data Book 1988.
[3] Source: 1990 Census of Population and Housing, STF3A on CD-ROM for counties, reservation, and Montana. City and County Data Book 1994 or Statistical Abstract of the United States 1993 for the United States.
[4] Source: Bureau of Economic Analysis Regional Economic Information System on CD-ROM, May 1993. (USDOC 1993)
[5] Source: 1990 Census of Population and Housing, STF1A on CD-ROM for counties, reservation and Montana. City and County Data Book 1994 for the United States.
[6] Source: USDI for Phillips County. Economic Consultants Northwest for other areas. (1991)
[7] Source: SBS Economic Consulting for Phillips County. Economic Consultants Northwest for other areas. (1991)
[8] On-reservation medical care provided by Indian Health Service.

NA - Data not available for this geographic level.

3.10.5.2 Social Well-Being in Blaine County

Table 3.10-18 presents information about social well-being in Blaine County much of which is available for the county as a whole (including the Fort Belknap Indian Reservation) but in some cases may not be available separately for the Fort Belknap Indian Reservation. The picture that emerges of this part of the study area is mixed. Educational attainment is much lower than the state and national averages, and the proportion of housing lacking some or all plumbing is higher than state averages. Blaine County as a whole has a much lower rate of physicians to population than the state and national averages. (This characteristic is not available for the Fort Belknap Indian Reservation, where medical care is provided by the IHS.) In Blaine County, per capita income in 1991 (not available for the Fort Belknap Indian Reservation) is lower than state and national averages and, in Blaine County and the reservation, median family income is also lower than both reference areas. In addition, the percent of families below the poverty line and the unemployment rate (both for 1989) were higher than state averages, especially on the Fort Belknap Indian Reservation, and out-migration in Blaine County for the available period was higher. On the other hand, the crime rate in Blaine County was lower than state averages. Again, positive characteristics are sparse population, plentiful opportunities for recreation, and a predominance of family ranching operations. In addition, persons on the Fort Belknap Indian Reservation receive targeted federal assistance for medical care, housing, nutrition, and education which can contribute to a higher level of social well-being.

3.10.5.3 Social Values in Phillips County

Residents of Phillips County place considerable value upon self-reliance, small-town life, and the availability of natural resources. Self-reliance is typified by the provision of many essential public safety and health services through volunteerism. Fire and ambulance services are all volunteer, and employers generally support their employees' obligation to be on 24-hour call. Phillips County residents also value the positive attributes of rural, small-town life such as good, friendly people; uncrowded surroundings; good schools for children; access to outdoor recreation; lack of crime, and lack of urban congestion. Negative attributes are lack of commercial transportation, limited availability of goods and services, lack of cultural activities, and an undiversified economy. For long-term residents of Phillips County, the positive attributes generally outweigh the negative. Natural resources and other aspects of the environment are important to Phillips County residents economically because many still rely on agriculture for a livelihood, for the recreational opportunities they afford, and for the appeal of undeveloped or minimally developed space (SBS Economic Consulting 1990).

3.10.5.4 Social Values in Blaine County

Social values in Blaine County vary among the three largest social groups: farmers and ranchers, townspeople, and Native Americans of the Fort Belknap Indian Community. Social values of Native Americans residing on the Fort Belknap Indian Reservation are described in Section 3.10.5.5. Blaine County farmers and ranchers are generally political conservatives whose predominant social values are frugality, self-reliance, and hard work. Independence and a close tie to the land are dominant elements of this group's lifestyle. Although independence is important to farmers and ranchers, social interchange is also valued (Economic Consultants Northwest 1991).

Townspeople of Harlem and Chinook value the attributes of local, small-town life: informal, personal interaction with others; knowledge and awareness of the personal and socioeconomic characteristics of neighbors; a quiet, predictable pace of life; mutual support among families and friends; volunteerism in the provision of essential public safety and social services; and religious affiliation. Lack of access to local shopping is somewhat offset by proximity to Havre (Hill County). However, the growth of the commercial sectors in Havre at the expense of stores in Chinook and Harlem is a source of concern and has stimulated concerted community action for economic development (Economic Consultants Northwest 1991).

3.10.5.5 Social Values of the Fort Belknap Native American Community

Most of the information presented in this section on social values of the Fort Belknap Native American Community has been paraphrased from available reports. The use of existing reports has been supplemented by a review and analysis of the public scoping meeting records, as well as by informal discussions with knowledgeable individuals selected due

to convenience, availability, and willingness to speak (Bigby 1993, King 1993, Spencer 1993). No additional formal research has been undertaken for this study to define (a) the social values of the Fort Belknap Indian Community in general, or (b) the community's attitudes toward mining in general and the Zortman and Landusky mines in particular.

The Fort Belknap Indian Community, centered on the Fort Belknap Indian Reservation, encompasses two tribal groups, the Assiniboine and the Gros Ventre, which have distinct tribal histories, experience, and concerns. The two tribal groups share a joint government and English as a primary language. Intermarriage also occurs between members of the two tribes. There is some geographic grouping by tribal affiliation within the Reservation: the Assiniboine have grouped near the Fort Belknap Agency, in Lodgepole and by Peoples Creek near Dodson; and the Gros Ventre have grouped at Hays near the Little Rocky Mountains, in Dodson and in Fort Belknap Agency housing. Within tribal groups, sub-groups may be defined by age, tribal blood degree, traditionalism, and assimilation. On-reservation residency of tribal enrollees has been increasing over the past two decades because of increased availability of jobs and housing (Economic Consultants Northwest 1991).

As a group, the Assiniboine characterize themselves as sticking together, getting along with one another, and looking for direction to the oldest, wisest and most spiritual among them (tribal elders). Native American religion and traditions are highly valued. As a group, the Gros Ventre characterize themselves as valuing occupational accomplishment, educational attainment and, to an extent, economic well-being. A tendency to compete with the majority culture and with other Native Americans is said to exist among the Gros Ventre (Economic Consultants Northwest 1991).

The Fort Belknap Indian Community also may be grouped in terms of attitudes toward the Zortman and Landusky mines, which have been a focus of attention within the Fort Belknap Indian Community since even before the advent of the Zortman mine expansion proposal. Some members of the Native American community object to the existing mine and the proposed expansion because of potential effects upon lifestyle and cultural values, the natural environment, and economic development potentials based on natural and cultural resources. Formal organizations have been among the most publicly outspoken groups within the community. Organizations opposing the existing mine and proposed expansion include Red Thunder, Inc., Island Mountain Protectors and Sprit Mountain Cultural Clan.

Part of the concern among Native Americans over the existing mine and proposed expansion is linked to use of locations in the Little Rocky Mountains for the practice of religion. Areas that are sought for such purposes are generally remote and usually free of modern land uses. These characteristics are sought because the activities Native Americans wish to pursue require uninterrupted solitude, availability of specific kinds of plants or other special and scarce resources. These locations have become less and less available with modern development and, therefore, more important to Native Americans. The activities that express traditional cultural values include vision questing, ceremonial sweats, collection of plants for ceremonial and medicinal purposes, and the collection of various minerals for paints. Native Americans do not usually equate the conduct of these activities with specific localities, but with a more generalized setting that affords the opportunities they feel are important (BLM 1987). The Little Rocky Mountains are such an area, according to comments made by many Native Americans. The reader would find more information on the uses of the Little Rocky Mountains by Native Americans in Section 3.12, Cultural Resources.

Strahn (1992) provides information on the meaning of mining in Little Rocky Mountains to the Fort Belknap Indian Community. According to Strahn, current attitudes toward the Zortman and Landusky mines grow from an ongoing sociocultural "revitalization movement" on the Fort Belknap Indian Reservation characterized by the revival of traditional customs, values and views of nature. Strahn says the reawakening of traditional values and practices in recent years has coincided with the resumption of heap-leach gold mining in the Little Rocky Mountains. In turn, cultural revival has fueled the environmental activism and opposition to mining which may be seen today within the Fort Belknap Indian Community: "In many respects the extent to which the Assiniboine and Gros Ventre again practice the religion of their ancestors echoes the degree to which there is a revised environmental awareness in their community ... This interrelationship is demonstrated in the case of Fort Belknap where an environmental crisis has helped promote and strengthen a religious revival in recent years" (Strahn 1992, p. 3).

At Fort Belknap, the synergy between cultural revival, environmentalism, and anti-mining sentiment stems from the "immense cultural significance [of the Little Rocky Mountains]" (Strahn 1992, p. 6). The Little Rocky Mountains are holy and sacred to the Fort Belknap tribes because of their historical and now reborn role as a wellspring, repository, and symbol of Native American tradition. According to Strahn, the Little Rocky

Mountains are "a place in which the Creator was more abundantly manifested" than anywhere else on earth, "a storehouse, cemetery, ceremonial arena, and sacred shrine" (Strahn 1992, pp. 5-6). This is reinforced by the century of tribal confinement to the reservation adjacent to the mountains without the benefits of ownership. In this context, the Little Rocky Mountains are both symbol and substance of tribal tradition, of the loss of traditional tribal resources and values, and of the potential to regain traditional values and restore continuity between present and past.

3.10.5.6 Ability to Adapt to Change in Phillips County

Information in this section is taken from the Judith Valley Phillips Resource Management Plan EIS, which in turn was based on discussions with area residents conducted by BLM employees in April, 1989 (BLM 1992b). Additional information was taken from the socioeconomic report of SBS Economic Consulting (1990). Note that the discussions with study area residents that are referenced in these sources were not specifically intended to assess the community's ability to adapt to change. The findings, as reported in the referenced documents, have been reinterpreted for use in this study.

In Phillips County, commercial mining and oil and gas production have been part of the local economy since the early 1900s. The gold district of the Little Rocky Mountains was in commercial production using a cyanide process almost continuously from 1903 until 1949. After a 30-year hiatus, gold mining resumed in 1979, when the Zortman and Landusky mines were opened in their current form. Bentonite mining and milling took place in Phillips County from 1979, until the mine was closed and the plant was torn down in 1988. The Bowdoin gas field, which is partly in Phillips County, has been in production since 1913 and continues to be the largest gas producer in the area. Two natural gas pipelines cross Phillips County, and their construction created short employment bursts: the Northern Border Pipeline segment of the Trans-Alaska Pipeline system in 1981 and 1982, and the Whitewater Gathering System from 1978 to 1986 (SBS Economic Consulting 1990).

Malta, the county seat and principal community, retains its identification with agriculture. Residents who discussed social conditions with the BLM in 1989 described Malta as a small, friendly, rural, and cooperative community. However, they noted several changes within the recent past that have affected community diversity and the distribution of power and resources within the community. Although Phillips County and Malta are considered progressive and have a good business climate, the economy is stagnant and young people often must leave because of the lack of job opportunities. Malta also has a growing elderly population because medical facilities and housing attract retirees from the surrounding countryside. Losing the bentonite plant in 1988 did away with a large number of relatively high-paying mining jobs. Although people employed at the Zortman and Landusky mines are a mainstay of the community, there has been an increase in the number of workers employed in recreation and tourism-related businesses.

Residents of Phillips County are independent and self-reliant, but social interchange is a valued part of local lifestyles. In the late 1970s and early 1980s, weekend dances in Malta attracted large local crowds. Today, with the population aging, residents increasingly depend on family and friends for security and support and on churches, school-based organizations, and volunteer service providers such as the fire department and the search and rescue group for social activity (Boothe 1994). Residents are well aware that decisions about mining, oil and gas, agriculture, and transportation that have a crucial effect on local economic well-being are made by corporations based elsewhere or by agencies subject to more outside than local influence (SBS Economic Consulting 1990).

In Phillips County, attitudes expressed toward mining in the 1989 interviews were generally positive. This was mainly due to the belief that the Zortman and Landusky mines have had a positive effect on the local economy. Some who had positive attitudes toward mining acknowledged having concerns about water quality and visual impacts; however, they seemed to feel the environmental effects of mining could be managed. There was also concern about the cyclical nature of mining and its potential for economic ups and downs due to forces beyond local control.

3.10.5.7 Ability to Adapt to Change in Blaine County

Information in this section is taken from the West HiLine Resource Management Plan EIS, which in turn was based on a study of Blaine County completed by ABT Associates in 1980 (BLM 1987). Additional information is taken from the socioeconomic report of Economics Consultants Northwest (1991).

Although Blaine County is mainly agricultural, mining has historically contributed to local economic development, and local attitudes toward mining reflect this belief. Commercial mining within the county has focused on oil, gas, and coal. Major oil and gas fields begun in the first half of the century are still in production. A refinery was in operation east of Chinook until the 1970s, and an asphalt plant fed by oil was in operation from 1961 to 1964. Commercial coal mining occurred from 1930 to 1970 near Chinook. Granite quarrying took place during the 1930s as part of the Fort Peck Dam project. Blaine County has also participated in the gold mining history of the broader region because it is adjacent to Little Rocky Mountains (Economic Consultants Northwest 1991).

The social structure of Blaine County is an adaptive one which addresses local issues through cooperative action and provides mutual support in the face of change that is beyond local control. Although people in the area are independent, social interchange is among the most valued elements of the local lifestyle. People know each other well and are part of networks of family and friends that provide a sense of security. In Blaine County, one may feel empowered within the local web of civic, social, fraternal and religious organizations. These groups have cooperated with each other to address community issues of housing and neighborhood revitalization and economic development. At the same time, residents are well aware that decisions about mining, oil and gas, agriculture, and transportation that have a crucial effect on local economic well-being are made by agencies and corporations appearing to have little affinity for local society (Economic Consultants Northwest 1990).

Local attitudes toward mining are generally positive. However, there is also a wariness towards mining because of its cyclical nature and potential to conflict with the recreation and visual resources that are an important part of the local sense of well-being.

3.10.5.8 Ability to Adapt to Change in The Fort Belknap Indian Community

Information in this section is taken from the economic and social section of the BLM's Judith-Valley-Phillips Resource Management Plan Management Situation Analysis (BLM 1989), the socioeconomics report of Economic Consultants Northwest (1991) prepared for Pegasus Gold, the work of Strahn (1992), and the West HiLine Resource Management Plan EIS (BLM 1987). Note that the discussions with study area residents that are referenced in these sources were not specifically intended to assess the community's ability to adapt to change. The findings, as reported in the referenced documents, have been reinterpreted for use in this study.

The Fort Belknap Indian Community looks back on a history of conflict with mining development. During the 1880s, widespread illegal mining occurred in the Little Rocky Mountains. In 1895, this led to the dispatch of a presidential commission to negotiate with the financially distressed Assiniboine and Gros Ventre for the cession of the mining district. In 1896, an agreement was reached by the tribes to sell 28 square miles for $350,000 including most of the Little Rocky Mountains. In the years since, attempts by the tribes to regain ownership of the land have been unsuccessful, but the effort has not been abandoned. The contemporary Zortman and Landusky mines have also been a source of conflict for the Fort Belknap Indian Community depending on how mining effects, including socioeconomic and environmental effects, are perceived.

The social structure of the Fort Belknap Indian Community is complex. Although divided in many ways, the community shows increasing evidence of group action on local issues. Reservation society is stratified by Native American versus non-Native American; tribal affiliation; whether one works for the Bureau of Indian Affairs or the Fort Belknap Indian Community Council; whether one is employed or unemployed; whether one has land or is landless; and by age, kinship, place of residence, and spiritual orientation. Most group action to promote economic well-being and solve social problems involves agencies of the Fort Belknap Indian Community Council. Recent examples include a drug abuse program, a joint housing initiative with the National Indian Housing Council, a parenting skills program for teens, a population and labor force census of enrolled members to support employment programs and grants, a campaign to save the IHS hospital, and the promotion of hunting, fishing, and tourism on the reservation (Economic Consultants Northwest 1991).

Attitudes toward mining within the Fort Belknap Indian Community are conditioned by the historical experience with mining in the Little Rocky Mountains. Today, the mines are accepted by some within the Fort Belknap Indian Community as a general economic benefit and source of employment. For others, the economic benefits do not offset attitudes of resentment and opposition. Strahn (1992) argues that opposition to mining in the Little Rocky Mountains on the reservation typically goes hand-in-hand with a revived adherence to native religious and secular traditions. The combination of the two represents a new political and cultural

consensus within the Fort Belknap Indian Community, according to Strahn.

Strahn also says that opposition to mining on the Fort Belknap Indian Reservation is a majority opinion. As evidence of this, he cites the recent defeat in a popular referendum of a proposal to allow mining on the reservation side of the Little Rocky Mountains. Opposition to mining also has been expressed by Red Thunder, Inc. and Island Mountain Protectors, private interest groups which are highly visible and make effective use of modern techniques of politics, communications, and laws to oppose mining and advance traditionalism.

To summarize, residents of Phillips and Blaine counties feel their way of life--small communities surrounded by a relatively unspoiled environment and outdoor recreation opportunities--is desirable. However, they observe with real concern the aging of the population and the out-migration of younger generations due to a lack of job opportunities. This leads to conflicts over resource development including mining. In general, residents favor economic growth through resource development or other industry because it would provide employment for them and their children and would promote overall economic well-being. On the other hand, they wish to continue to enjoy the lifestyle associated with outdoor recreation, sparse population, and undeveloped natural surroundings.

The Fort Belknap Indian Community is also torn over the mining issue, but in a different way. Like the surrounding Euro-American communities, the Fort Belknap Native Americans are concerned about a lack of economic opportunity for young and old alike. However, this is offset by opposition to mining in the Little Rocky Mountains because of the environmental concern and activism that have accompanied a revival of traditional Native American beliefs, values, and culture, and because of a longstanding goal to restore to tribal ownership the land that contains the Zortman and Landusky mines.

3.11 TRANSPORTATION

This section describes both the historic and current transportation network which provides access to the Zortman/Landusky project area and other portions of the Little Rocky Mountains in the vicinity of the project area. Discussions address road conditions, maintenance responsibilities, traffic volumes, problems with accidents, inclement weather, transport of hazardous materials, and other transportation issues. This discussion focuses primarily on roads that (a) provide access to the proposed extended Zortman and Landusky mining operations; and (b) those which serve local communities, such as Zortman, Landusky, Lodgepole, and Hays.

3.11.1 Study Area

The study area for transportation includes major highways and minor roads in Blaine and Phillips counties that provide access to the Zortman/Landusky project area. Regional highways and roads provide the primary means of access in and out of the project area while local roads provide access to the communities of Zortman and Landusky, as well as the southern Little Rocky Mountains including the Zortman/Landusky mining areas. Due to the fact that potential transportation impacts are most likely to occur near the mine sites on roads that access the Little Rocky Mountains and local communities, more detail will be given for the roads that serve that portion of the overall study area.

3.11.2 Transportation Network in the Project Region

3.11.2.1 Major Highways

State and federal highways provide the main access routes to the project region. The major transportation network in the study area consists of three highways: U.S. Highway 2, an important east-west transportation route which traverses Blaine and Phillips counties roughly 40 miles to the north of the project area; U.S. Highway 191, which is the primary access route to the Zortman area; and State Route 66, which runs north-south through the Fort Belknap Indian Reservation and provides primary access to the communities of Harlem, Hays, and Landusky. Descriptions of each highway are presented below. These highways are maintained by the Montana Department of Transportation. Historic and current traffic counts (1975 to 1993) for each of these highways are provided in Table 3.11-1.

U.S. Highway 2 is an important east-west transportation route, following the HiLine across northern Montana. It is a paved, two-lane undivided highway serving the communities of Chinook, Harlem, Fort Belknap Agency, Dodson, and Malta in the study area. Despite its regional significance, traffic volumes along this highway are low, averaging roughly 3,770 vehicles per day near Harlem in 1993 (MDOT 1994). In terms of traffic hazards and accidents, U.S. Highway 2 averaged 14 accidents per year during the 1980-1989 time period (MDOT 1991).

U.S. Highway 191 is the primary route connecting the project area and the Little Rocky Mountains with larger service areas such as Malta and Lewistown. It is a paved, two-lane undivided highway. In general, traffic volumes along this highway are low due to the sparse population of the area it serves. In 1993, average daily traffic on this highway was approximately 426 vehicles per day (MDOT 1994). U.S. Highway 191 is generally well maintained and kept open on a year-round basis, although it is subject to brief closures during heavy storm events. In terms of traffic hazards and accidents, U.S. Highway 191 averaged 13 accidents per year during the 1979-1989 time period (MDOT 1991).

State Route 66 provides access to the Landusky and Zortman areas and the Little Rocky Mountains from the north and west. It runs through the Fort Belknap Indian Reservation and is used primarily by residents of the reservation. It is a paved, two-lane undivided highway. Traffic volumes on this highway are low due to the sparse population of the area it serves. In 1993, average daily traffic was approximately 415 vehicles per day (MDOT 1994). In terms of traffic hazards and accidents, State Route 66 averaged 5 accidents per year during the 1980-1989 time period (MDOT 1991).

3.11.2.2 Local Roads

Aside from the major highways described above, the vast majority of roads in the project region are gravel-surfaced or dirt roads designed to service sparsely populated areas, small scale economic activities, and recreational use of the Little Rocky Mountains. Local roads are generally maintained by the counties, although local roads within the Fort Belknap Indian Reservation are maintained by the reservation. Roads within the Zortman/Landusky mining areas are maintained by Zortman Mining, Inc. Figure 2.5-2 provides a map of local roads in the study area.

In terms of project area access, the town of Zortman and the Zortman Mine can be reached by two local

TABLE 3.11-1
AVERAGE DAILY TRAFFIC IN THE ZORTMAN/LANDUSKY STUDY AREA

Highway	ADT 1975	ADT 1980	% Change 1975-1980	ADT 1985	ADT 1990	% Change 1980-1990	ADT 1993
U.S. 2[1] E. of Harlem	1,812	2,320	28%	2,300	2,520	9%	3,770
Route 66[1] between Hays and Landusky Rd.	180	420	133%	630	500	19%	415
U.S. 191[2] SW. of Zortman	220	310	41%	270	390	26%	426
U.S. 191[2] NE. of Zortman	222	560	152%	350	400	-28.6%	---

[1] Montana Department of Highways, Safety Management Section, Helena. April 1991. Unpublished traffic and accident data.
[2] Montana Department of Highways, Safety Management Section, Helena, April 1990. Unpublished traffic and accident data.

ACCIDENT HISTORY OF ROADS IN THE ZORTMAN/LANDUSKY MINE EXPANSION STUDY AREA

	Before Active Mining		Active Mining		Active Mining	
Highway	Average Annual Accidents 1972-1978[3]	Accident Rate 1972-1978 (per million trips)	Accidents 1980	Accidents 1989	Average Annual Accidents 1980-1989	Accident Rate 1980-1989 (per million trips)
U.S. 2[1], E. of Harlem	31	47	16	10	14	16
Route 66[1]	13	198	3	9	5	30
U.S. 191[2], S. of Malta	14	173	---	---	13	74

[1] Montana Department of Highways, Safety Management Section, Helena. April 1991. Unpublished accident data.
[2] Montana Department of Highways, Safety Management Section, Helena. April 1990. Unpublished accident data.
[3] Montana DOT Highway Patrol, Unpublished Traffic and Accident Data, Compiled 1994.

roads from U.S. Highway 191. A dirt road also runs to the Zortman Mine from Landusky and the Landusky Mine. Prior to commencement of mining activities in 1979, this road was also open for public use. The road was subsequently closed to the public. The following is a description of the local roads used to access Zortman and the Zortman Mine, and Landusky and the Landusky Mine.

Bear Gulch Road crosses through the southeast corner of the Fort Belknap Indian Reservation and is the best route to Zortman from Malta and other areas to the northeast. It is paved from Highway 191 to its intersection with Seven Mile Road. From the intersection to the town of Zortman, the road is gravel-surfaced. Bear Gulch Road is often impassable during winter months due to snow. Steep grades and winter driving hazards preclude the use of this road by trucks. All trucks bound for the town of Zortman and the Zortman Mine use Seven Mile Road.

Seven Mile Road extends due north from U.S. Highway 191 to Zortman and is maintained by Phillips County. It is kept open on a year-round basis although it is sometimes closed temporarily due to drifting snow.

Zortman Mine Access Road extends up Ruby Gulch from the Town of Zortman to the Zortman Mine. It is a crushed-rock/gravel-surfaced road that has been closed to the public since mining resumed in 1979. The access road grade does not presently exceed 10 percent. The road is maintained by the mine and is open on a year-round basis with the exception of heavy snow storms that temporarily restrict access.

Landusky Access Road is a gravel road that provides vehicular access to the community of Landusky from State Route 66. The access road is roughly four miles in length. The road continues east to the Landusky Mine, although public access has been restricted above the community of Landusky since mining resumed in 1979.

Mission Canyon Road provides access to the Landusky Mine from Hays and the Fort Belknap Indian Reservation. The road is paved from Hays to near the entrance to Mission Canyon and is dirt from that point to its terminus at the Landusky Mine. This road is used primarily by the public for cultural and recreational activities in Mission Canyon. Historically, this road was open to the general public over its entire length. At present, public access to the Landusky Mine is restricted by a gate near the top of Mission Canyon. A small number of workers commute up this road from the Hays area to the Landusky Mine when the weather permits.

3.11.2.3 <u>Other Transportation Systems</u>

Rail service in the study area is provided by the Burlington Northern Railroad for shipment of freight and by AMTRAK for passenger service. Both railroads run along an east-west route, known as the "HiLine," that parallels U.S. Highway 2 roughly 40 miles north of the Zortman area. With respect to Zortman, the closest freight and passenger rail stop is located in the City of Malta.

Commercial bus service is offered in Havre, roughly 95 miles northwest of Zortman. Passengers who board the bus in Havre then ride to Great Falls, where they can transfer to buses traveling elsewhere. No commercial bus service is available in Zortman, Landusky, Hays, Lodgepole, Malta or Harlem.

Commercial airline service has been available in recent years in Lewistown, Havre, and Glasgow. In addition, various small airstrips are present, including a landing strip at Zortman owned by ZMI. Passengers who wish to travel by air to destinations outside of the region must drive to Lewistown, Havre, Glasgow, Great Falls or Billings, where commercial airline service is connected to the nationwide network. Charter air service is available in Malta, Chinook, Glasgow, Havre, and Lewistown.

In general, rail, bus, and aircraft do not provide significant transportation services that are related to the operations of the Zortman and Landusky mines. The vast majority of project-related transportation trips utilize automobiles and trucks.

3.11.3 Transportation of Hazardous Materials

Prior to 1979, when the Zortman and Landusky mines began full-scale operations, there was minimal transportation of hazardous materials in the local Zortman/Landusky project area. The only notable exception was the transport of motor fuel in relatively small quantities to two local vendors in Zortman which sold fuel to the general public.

Since commencement of mining by ZMI in 1979, the Zortman and Landusky mining operations have used several reagents which are regulated hazardous materials. All of these materials are transported to the mines by trucks using the regional highways and local roads described above. Table 3.11-2 provides a summary of regulated reagents used by the mines since 1979, the present annual number of trips to the mines, and the transportation routes used to deliver them.

TABLE 3.11-2
SUMMARY OF TRANSPORTATION ROUTES AND HAUL TRIPS FOR HAZARDOUS REAGENTS USED BY THE ZORTMAN AND LANDUSKY MINES

Reagent	Transportation Route	Annual Trips to Zortman Mine Present	Annual Trips to Zortman Mine with Expansions	Annual Trips to Landusky Mine Present and with Expansion
Gasoline	Billings north to Zortman/Landusky along U.S. 87 and U.S. 191 (Truck)	4	48	50
Diesel	Billings north to Zortman/Landusky along U.S. 87 and U.S. 191 (Truck)	2	140	260
Oil and Lubricants	Billings north to Zortman/Landusky along U.S. 87 and U.S. 191 (Truck)	10	80	160
Antifreeze	Billings north to Zortman/Landusky along U.S. 87 and U.S. 191 (Truck)	5	18	17
Cyanide	Port of Butte north to Great Falls I-15, east to Lewistown U.S. 87 and north to Zortman/Landusky U.S. 191 or Port of Butte east to Big Timber I-90 and north to Zortman/Landusky on U.S. 191 (Truck)	2	300	87
Lime	Townsend north to Zortman/Landusky along U.S. Highway 12 and 191 (Truck)	6	1,800	900
Ammonium Nitrate	Butte north to Great Falls I-15, east to Lewistown U.S. 87 and north to Zortman/Landusky on U.S. 191 or Butte east to Big Timber I-90 and north to Zortman/Landusky U.S. 191 (Truck)	0	350	200
Hydrochloric Acid	Billings north to Zortman/Landusky along U.S. 87 and U.S. 191 (Truck)	6	13	5
Sodium Hydroxide	Billings north to Zortman/Landusky along U.S. 87 and U.S. 191 (Truck)	2	2	0

TABLE 3.11-2
(Concluded)

Reagent	Transportation Route	Annual Trips to Zortman Mine Present	Annual Trips to Zortman Mine with Expansions	Annual Trips to Landusky Mine Present and with Expansion
Anti-Scalants	Billings north to Zortman/Landusky along U.S. 87 and U.S. 191 (Truck)	1	25	8
Flocculents	Billings north to Zortman/Landusky along U.S. 87 and U.S. 191 (Truck)	1	1	1
Calcium Hypochlorite	Billings north to Zortman/Landusky along U.S. 87 and U.S. 191 (Truck)	1	1	0
	TOTAL	38	2,778	1,688

Source: Zortman Completeness Review Responses No. 2, 1992.

3.12 CULTURAL RESOURCES

Cultural resources are broadly defined as cultural properties and traditional lifeway values, and are further defined by the BLM Manual, Section 8100 (BLM 1988), as follows:

> Cultural property: a definite location of past human activity, occupation, or use identifiable through field inventory (survey), historical documentation, or oral evidence. The term includes archaeological, historic, or architectural sites, structures, or places with important public and scientific uses, and may include definite locations (sites or places) of traditional cultural or religious importance to specified social and/or cultural groups. Cultural properties are concrete, material places and objects.
>
> Traditional lifeway value: the quality of being useful in or important to the maintenance of a specified social and/or cultural group's traditional systems of (a) religious belief, (b) cultural practice, or (c) social interaction, not closely identified with definite locations.

Cultural properties are considered by the National Historic Preservation Act (NHPA) and implementing regulations at 36 CFR 800. Certain traditional lifeway values are addressed by the American Indian Religious Freedom Act (AIRFA). While the significance of cultural properties has been well defined and protection steps codified, protection offered to traditional lifeway values has been interpreted much more broadly under AIRFA than under NHPA.

The discussion of baseline cultural resources for the Zortman mine extension project and Landusky Mine reclamation has been divided into three sections: prehistoric (archaeological) resources, historic resources, and ethnographic or traditional Native American resources. Studies have been conducted in the Zortman and Landusky vicinity to locate, record, and evaluate all three of these resource types, and to include archaeological and historic field surveys, historic records searches, and interviews with Native Americans (ethnographic studies). Native American cultural resources include the values Native Americans associate with each resource or resource class.

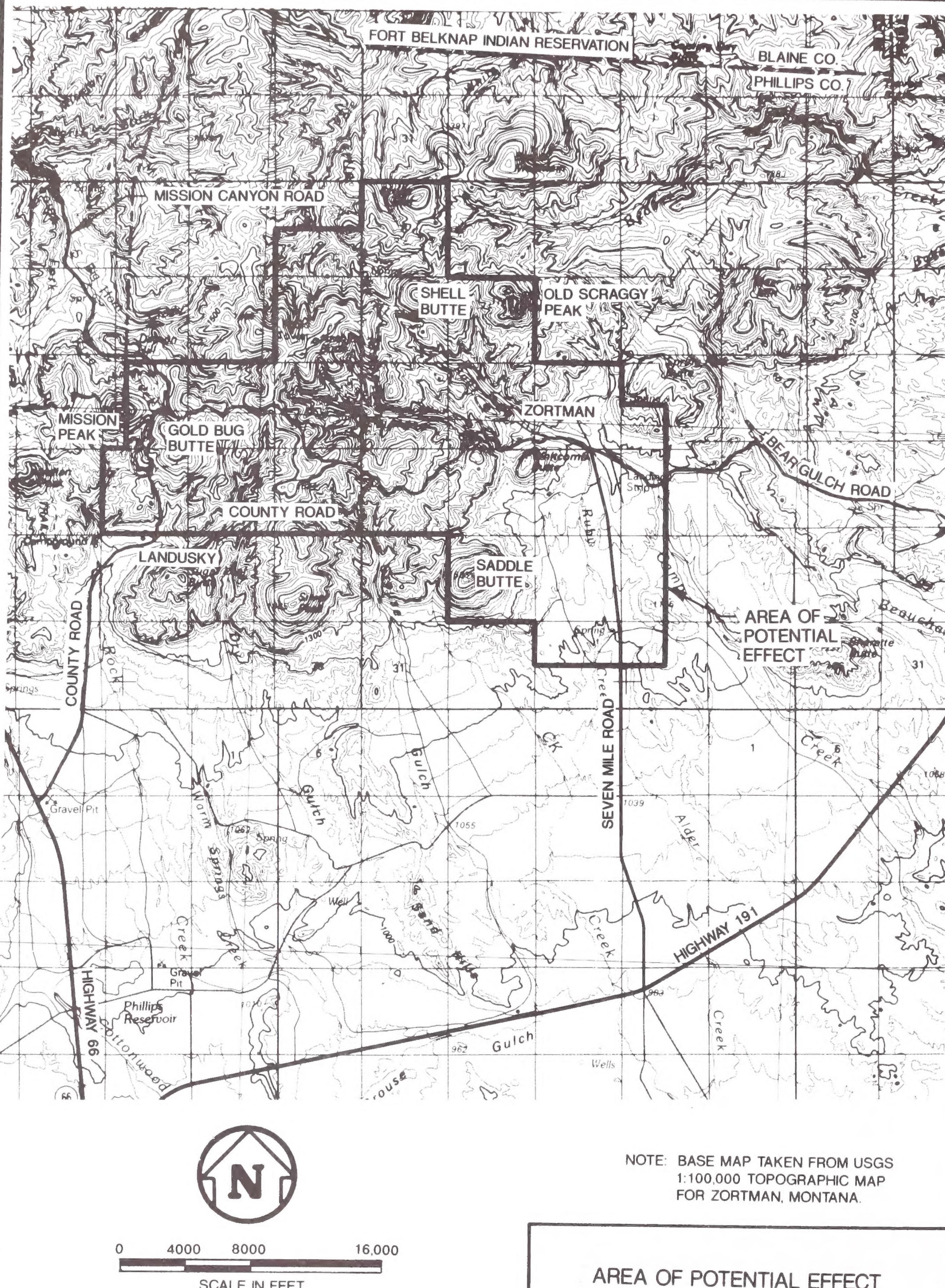
The BLM has defined an Area of Potential Effect (APE) for cultural properties, primarily archaeological and historical resources (see Figure 3.12-1), containing approximately 12,800 acres. Both direct and indirect impacts within the APE would be analyzed. Deaver and Kooistra (1992) note that many traditional Native Americans believe the Little Rocky Mountains are all interconnected (spiritually and physically), and one peak or butte cannot be separated from the range as a whole. This concept has been reiterated in the scoping meetings and subsequent interviews. Therefore, a larger study area has been used for analysis of impacts to these Native American cultural resources and the values associated with them.

3.12.1 Regulatory Setting and Significance Criteria

The key legislative directives for identifying and protecting historic properties are provided in Section 106 of the NHPA. Regulations implementing this legislation are found at 36 CFR 800. These regulations define procedural requirements for federal agencies to consult with the State Historic Preservation Office (SHPO), the Federal Advisory Council on Historic Preservation (Council), and other interested parties to ensure that historic properties are duly considered as federal projects are planned and implemented. These requirements are in addition to consideration given all resources under NEPA. The steps in the Section 106 consultation process are as follows:

- Define the Area of Potential Effect (APE);
- Identify and evaluate cultural properties that may be affected by a proposed undertaking;
- Assess the potential effects of the undertaking on historic properties;
- Consult with the SHPO, Council, and other appropriate interested parties to determine ways to avoid or reduce any adverse impacts if significant properties are identified;
- Provide the Council a reasonable opportunity to comment on the proposed undertaking and impacts to significant properties; and
- Proceed with the undertaking under the terms of the Programmatic Agreement or taking into account Council comments, as required.

Cultural properties are identified as significant if they are determined eligible for inclusion in the National Register of Historic Places, a listing of historic properties established by the NHPA. Eligible properties include buildings, structures, sites, and groups of such resources forming historic districts, as well as objects and landscapes that are significant in American history,



NOTE: BASE MAP TAKEN FROM USGS 1:100,000 TOPOGRAPHIC MAP FOR ZORTMAN, MONTANA.

AREA OF POTENTIAL EFFECT

FIG. 3.12-1

architecture, archaeology, engineering, and culture.

Properties may be considered eligible for inclusion in the National Register if they possess integrity of location, design, setting, materials, workmanship, feeling, and association. Properties must also meet at least one of the following four criteria listed in 36 CFR 60.4:

(a) Associated with events that have made a significant contribution to the broad patterns of our history;

(b) Associated with the lives of persons significant in our past;

(c) Embody the distinctive characteristics of a type, period, or method of construction; represent the work of a master; possess high artistic values; or that represent a significant distinguishable entity whose components may lack individual distinction; or

(d) Have yielded, or may be likely to yield, information important in prehistory or history.

Properties determined eligible according to these significance criteria are termed "historic properties." Sites that have been determined not eligible under all of the criteria require no further consideration under NHPA. However, access to certain locations may be protected under the American Indian Religious Freedom Act (AIRFA). These locations would not necessarily be eligible to the National Register.

Sites and localities having significance to a group of Native Americans may have cultural importance and historic significance. To be eligible for the National Register, a site (place) must be significant to a group of people, not just to an individual. The site must have been significant through time, not just recently used. Sites of solely cultural significance (but not historic significance) are not eligible for the National Register, but may still be considered under AIRFA. Sites with historic significance may be eligible for the National Register in accordance with the significance criteria outlined in 36 CFR Part 60.4. In 1990, the National Park Service issued National Register Bulletin 38 (Parker and King 1990) which provides expanded guidance (not regulations) on assessing resource significance, particularly when applying criteria (a), (b), and (c) (36 CFR 60.4), in terms of the culture which generated the site. Bulletin 38 generally defines a Traditional Cultural Property (TCP) as one that is eligible for inclusion in the National Register based on its association with historically rooted cultural practices or beliefs of a living community that are important in maintaining the community's cultural identity. Like all sites eligible for the National Register, TCPs must retain integrity of location, setting, feeling, and association.

According to Bulletin 38, in order for a resource (most often a site, district, landscape, or object) to be recommended for National Register listing as a TCP, it must have a tangible property referent and demonstrate integrity of relationship and integrity of condition. Integrity of relationship is realized if the property is recognized by contemporary groups as being important to their cultural heritage, and the tie between the two must generally be at least 50 years old. Integrity of condition is demonstrated if the resource physically retains the qualities making it significant to the traditional group.

AIRFA of 1978 reaffirms the rights of Native Americans to believe, express, and exercise their traditional religion and, like the NHPA, requires that federal agencies take into account the effects of their undertakings on traditional religious practices (lifeway values). AIRFA includes two types of significant resources not defined as TCPs under the NHPA: (1) resources associated with traditional spiritual activities that are less than fifty years old and (2) sites with strictly intangible spiritual values associated with particular locations, i.e., sites that lack a demonstrable tie between a thing at the location--either natural or man-made--and a spiritual value.

The Religious Freedom Restoration Act of 1993 was enacted by Congress to protect the free exercise of religion. This Act recognizes that laws "neutral" toward religion may burden religious exercise, and mandates that governments should not substantially burden religious exercise without compelling justification. Compelling justification, as determined by the government, is if the application of the burden is in furtherance of a compelling government interest and is the least restrictive means of furthering that compelling governmental interest.

3.12.2 Prehistoric Cultural Resources

3.12.2.1 Introduction

A number of archaeological surveys have been conducted in the Little Rocky Mountains since 1978 to locate, record, and evaluate prehistoric resources, historic sites and traditional cultural properties.

3.12.2.2 Prehistory of the Little Rocky Mountains

The native population of North America responded to the changing physical and cultural environment to sustain their lifestyles. Archaeological evidence (the physical remains of human activity) and native oral tradition are the only records available prior to the coming of the Europeans to this continent. While the archaeological record reveals environmental conditions as well as subsistence patterns, more detailed, intimate information (e.g., language, religion, traditions) is often lacking and, therefore, open to supposition. Likewise, concrete evidence for ancestral ties between prehistoric people and extant Native American groups is scarce. Archaeological evidence can be supplemented with ethnographic research, especially for information pertaining to the latest period of occupation.

Early occupation of north-central Montana dates to a period of circa 11,000 to 8,000 years before present (BP), and has been identified as the Early Prehistoric Period (Brumley and Rennie 1993). Big game, including now-extinct mammals, apparently formed the subsistence base for the people of this period, generally called Paleoindians. Evidence for occupation in this part of Montana is limited to distinctive projectile point (spear) types that can be related to more extensive sites excavated elsewhere in the Northern Great Plains. No projectile points from this period have been reported from the Little Rocky Mountains.

The Middle Prehistoric Period is generally dated from circa 8,000 to 1,300 years BP. During this period the subsistence base expanded to include smaller game and more plant resources, although bison hunting remained the primary focus on the Northern Great Plains. There is some evidence of communal efforts to hunt groups of large mammals in the later part of the period. Sites dating to this period are often characterized by projectile points that presumably were designed to be used with a spear (or dart) thrower (atlatl).

The Late Prehistoric Period dates from circa 1,300 years BP to historic contact, which occurred in the general project area in 1805 with the Lewis and Clark expedition. Bison hunting remained the primary subsistence activity with many of the sites exhibiting evidence of communal behavior (Brumley and Rennie 1993). The bow and arrow became the hunting weapon of choice, and some groups utilized pottery. The ceramics were strongly related to Middle Missouri ceramics, suggesting trade with and migration from the east. The horse and Euro-American trade goods began filtering into the area in the early part of the eighteenth century resulting in drastic changes in the lifestyles of the native population.

3.12.2.3 Inventory

Ruebelmann (1983) hypothesized that the island mountains of north-central Montana were used only on a seasonal basis by the native prehistoric inhabitants. They visited the mountains for the resources contained therein and spent much more time on the plains and in the river bottoms. The types and numbers of sites located during inventories of the APE would seem to support this hypothesis.

All areas subject to physical impact in the APE have been surveyed to BLM Class III standards for prehistoric resources. No prehistoric sites were recorded by Hogan and Fredlund (1978) prior to commencement of surface mining by Pegasus. Rossillion (1993) recorded nine prehistoric sites, six of which consisted of one or more stone circles and other stone alignments/piles. Only two temporally diagnostic artifacts were recovered, suggesting occupation/use in the Late Prehistoric Period. Only one stone circle site (24PH2905) within the APE had enough artifactual material associated to recommend the site as eligible to the National Register. One other campsite (24PH2794) within the APE was also recommended as eligible. Eight of these sites are located in the APE, clustered in the southeast portion of the APE. Generally, the topography here is gentler, and at a lower elevation than much of the APE.

Munson (1994) has recently surveyed a possible waste rock repository location on Goslin Flats and recorded a single site (24PH3203). It consists of a large pile of rocks, tentatively identified as a collapsed structure or large hearth. It has been recommended as eligible to the National Register.

3.12.3 Historic Cultural Resources

3.12.3.1 Introduction

The APE for historic resources is the same as that described in Section 3.12 and depicted on Figure 3.12-1.

3.12.3.2 History of the Little Rocky Mountains

The following brief historic overview is taken mainly from the section written by Robert Murray in Hogan and Fredlund (1978), and from Deaver and Kooistra (1992). Additional information on the ethnographic history of the Little Rocky Mountains is included in Section 3.12.4.3.

Early recorded intrusions by non-Native Americans into the general area were by the Lewis and Clark expedition of 1805, although Lewis and Clark did not explore the Little Rocky Mountains. The archaeological and ethnographic records indicate that the general area had been occupied for thousands of years previously, and was occupied at the time of Euro-American exploration and use. Following exploration, early Euro-American use of the Little Rocky Mountains in the first part of the nineteenth century was by fur trappers, with prospectors following in the last decades of the century.

The first sustained Euro-American use of the Little Rocky Mountains was in 1884, when Pike Landusky and others developed the first paying placer mines in Alder Gulch, leading to the development of the town of Landusky. Landusky later staked the first patented lode claims in the Little Rocky Mountains (recorded in 1892), as the early placer workings had rapidly been depleted. The richest claim was the August, patented in 1893, on the Fort Belknap Indian Reservation. Because of the increased mining activity in the Little Rocky Mountains, Montana politicians influenced the establishment of a commission to negotiate further land concessions from the Native Americans. The result was the Grinnell Agreement of 1896, in which the Native Americans at Fort Belknap ceded a portion of the Little Rocky Mountains from the southern part of the reservation to the U.S. government for $360,000. Records indicate there was substantial pressure put on the Native Americans to cede this land, and the vote among the Gros Ventre and Assiniboine was not unanimous. Some accounts note that the Gros Ventre were especially upset, as they were generally inhabiting the area closer to the mine development, and had plans of their own to mine the gold (Strahn 1993). (See also Sections 3.12.4.3 and 3.12.4.6.)

Mine and mill development proceeded through the first two decades of the twentieth century. Zortman was established as a mining camp in 1903 with the construction of a cyanide mill in Alder Gulch. Other stamp and crusher mills were constructed (the Ruby Gulch Mill as one of the larger ones), processing ore from the Ruby and Independent mines. Ore processing included the use of cyanide which had been utilized in the Little Rocky Mountains since the 1890's. Zortman grew faster than Landusky or Whitcomb (abandoned in the 1940s), although growth was as sporadic as work in the mines. From the 1920s through 1942, mining could be characterized as cyclical. Ventures were formed with some development and production; however, production did not usually continue for more than a few years. The ore in the Little Rocky Mountains was not of consistently high quality to sustain most of the mines utilizing the mining techniques of the day. Additionally, sporadic fires impacted both towns and mining operations. Much of Zortman burned in 1929, and the 1936 fire burned over 23,000 acres of timber.

Mining continued sporadically through 1951, with a hiatus during World War II. After 1951, little serious activity occurred here until the modern, surface-mining operation opened in 1979. It has been estimated that over 380,000 ounces of gold were mined from the Little Rocky Mountains prior to 1979, contributing significantly to the region's economy.

3.12.3.3 Inventory

All areas of potential impact have been surveyed for historic properties, except the Seaford Clay Pit. Numerous sites relating to historic mining have been recorded in the APE. These sites include mines, mills, trash scatters, adits, exploration pits, a kiln, water control devices, structure foundations, and residential/commercial structures. Two homesteads/ranches have also been recorded, along with the Zortman jail and ranger/fire station. Table 3.12-1 lists the historic sites recorded in the APE. This table also lists the National Register status of each site. BLM and the SHPO have determined there is one historic district eligible for the National Register within the APE. There are twelve individual sites included in the Alder Gulch Historic District; they are noted with a single asterisk in Table 3.12-1. Another proposed district is the Beaver Creek District, located outside the APE. Other historic sites proposed as eligible for the National Register within the APE include the Ruby Creek Mill (24PH255), site 24PH2849 (a mining camp), the Zortman Ranger Station (24PH2151), and 24PH2938 (a placer mine).

TABLE 3.12-1
HISTORIC SITES WITHIN THE AREA OF POTENTIAL EFFECT (APE)

Site No.	Type/Name	NR Eligibility (Agency/ SHPO Concurrence)
24PH254	Gold Bug Mine	No
24PH255	Ruby Mill	Yes
24PH256	August Mine	No
24PH257	Little Ben Mine	No
24PH2151	Zortman Ranger Station	Yes
24PH2184	Mining Camp	No
24PH2195	Zortman Jail	No
24PH2293	Cabin	No
24PH2295	Prospects	No
24PH2296	1930s Mining Camp	No
24PH2297	Prospect	No
24PH2298	Prospect	No
24PH2299	1940s Mining Camp	No
24PH2774	Adit	No
24PH2817	Ragtown	No
24PH2818	Mine	No
24PH2819	Runyon Place	No
24PH2820	Adit	No
24PH2821	Adits	Yes*
24PH2822	Mining Camp	Yes*
24PH2823	Mining Camp	Yes*
24PH2824	Alder Gulch Dam	Yes*
24PH2825	Miner's Shack	Yes*
24PH2826	Adit	Yes*
24PH2830	NE Landusky Residences	**
24PH2831	Mining Camp	Needs testing
24PH2832	Dam	No
24PH2833	Dump	**

TABLE 3.12-1 - HISTORIC SITES WITHIN THE APE (Continued)

Site No.	Type/Name	NR Eligibility (Agency/ SHPO Concurrence)
24PH2834	Adit	No
24PH2835	Adit	No
24PH2840	Mission Peak Fire Tower	No
24PH2841	Adit	No
24PH2845	Hawkeye Mine/Mill	No
24PH2848	Adit	No
24PH2849	Mining Camp & Foundation	Yes
24PH2850	Mining Camp	No
24PH2851	Pumphouse, 3 Adits	No
24PH2852	Adit	No
24PH2853	Adit	No
24PH2854	Adit	No
24PH2855	Mining Camp	Needs testing
24PH2856	Mining Camp	No
24PH2857	Adit	No
24PH2859	Mining Camp	No
24PH2860	Mining Camp	Yes *
24PH2862	Alder Gulch Mill & Camp	Yes *
24PH2863	Alder Gulch Lime Kiln	Yes *
24PH2864	Pony Gulch Adit	Yes *
24PH2865	Pole Gulch Mine	Yes *
24PH2866	Dump	No
24PH2867	Adit	Yes*
24PH2869	Ruby Gulch Dam	No
24PH2904	Sturman Ranch/Homestead	No
24PH2907	Goslin Ranch	No
24PH2936	Placer Mine	No
24PH2937	Prospect Field	No

TABLE 3.12-1 - HISTORIC SITES WITHIN THE APE
(Concluded)

Site No.	Type/Name	NR Eligibility (Agency/ SHPO Concurrence)
24PH2938	Placer Mine	Yes
24PH2939	Mine	No
24PH2940	Post-WW II Mine	No
24PH2942	Placer Mine Camp	Not determined ***
24PH2947	Trash Dump	Not determined ***
24PH2948	Cabin and Foundations	Not determined ***
24PH257	Little Ben Mine	No
24PH3024	Drainage Barriers	No
24PH2821	3 Adits	No

* Components of the Alder Gulch Historic District
** Recommended as not eligible by consultant and BLM, no comment has been received from SHPO.
*** BLM and SHPO have not resolved the eligibility.

3.12.4 Native American Cultural Resources

3.12.4.1 Introduction

An ethnographic overview of the Little Rocky Mountains prepared by Ethnoscience (Deaver and Kooistra 1992) is the major reference for this section. Additional information is taken from Flemmer (1990, 1991), Melton 1990, 1993), Strahn (1992, 1993), Woods (1981), and supplementary sources as referenced. The original intent of the Deaver and Kooistra ethnographic study was to document the presence or absence of Traditional Cultural Properties (TCPs) in the proposed Zortman mine extension study area, located just south of the Fort Belknap Indian Reservation. The study area was expanded to include most of the Little Rocky Mountains, as well as a few locations beyond. This expansion of the study area allowed for the development of a larger comprehensive context, and a broader-based understanding of traditional cultural use and patterned distribution of TCPs than was previously recognized (Deaver and Kooistra 1992:1.10).

The Deaver and Kooistra study (1992) included a cultural resources file search at the Montana SHPO. Appropriate BLM and BIA reports were consulted as well. An extensive review of ethnographic, ethnohistoric, historic and other relevant literature for the study area was completed. Interviews with 54 Native Americans and other knowledgeable individuals were undertaken, with some interviews involving field reconnaissance. The majority of the interviewees are members of the Fort Belknap Indian Community, with the remainder being members of Native American tribes outside Fort Belknap, including the Assiniboine at Fort Peck, Blackfeet, Chippewa-Cree, Crow, and Northern Cheyenne. In addition to the ethnographic research, nine archaeological sites were visited and recorded.

3.12.4.2 Data Collection

The Deaver and Kooistra ethnographic overview is primarily a review of previous research in the area, and although they did interview a number of Native Americans regarding Native American resources in the Little Rocky Mountains, the intent was not to compile an exhaustive inventory of these resources. For the purposes of this EIS, the inventory data are adequate to represent the Native American cultural resources and associated Native American values extant in the Little Rocky Mountains.

Information collected from public meetings on the Reservation and discussions with Native American groups and individuals revealed the range and intensity of concerns held by some of the Fort Belknap Gros Ventre and Assiniboine residents.

3.12.4.3 Ethnohistory of the Little Rocky Mountains

Most of the data used to identify the ancestors of modern tribal groups is based upon linguistic associations. Some researchers postulate that Algonkian speakers (contemporary groups include the Blackfeet, Arapaho, Gros Ventre, Cheyenne, Cree, and Chippewa) were in the Northern Plains prior to AD 1300, while others assert that Athapaskan speakers, ancestors to the Apache and Navajo, were also present.

By the 1400s, the Blackfeet had reached the plains just north of central Montana. During the 1500s, Salish and Kootenai groups apparently expanded their territories east of the Rockies, and the Bannock moved into western Montana. Also during the 1500s, westward migrations into eastern Montana increased, particularly for the Mountain Crow who entered the area in the 1550s following bison migrations. During the 1600s, the Mountain Crow expanded southwest along the Yellowstone River. The River Crow moved into central Montana after 1670. The Sioux also began pushing westward to escape conflicts with the Chippewa and to follow bison onto the plains.

By 1700, the Gros Ventre, coming from northern Minnesota, and the Arapaho shared territory ranging from eastern North Dakota to the eastern Montana border. In the 1720s, the Gros Ventre and Arapaho separated, with the Gros Ventre moving north into Canada and the Arapaho, by the end of the 18th century, moving into northeastern and central Montana. Also in the 1720s, the Plains Cree moved toward Blackfeet lands. After the Shoshone received horses from the Spanish in the 1720s, they controlled much of the High Plains including northern Montana. By the 1750s the Gros Ventre and Blackfeet alliance had obtained guns and horses and began to reclaim their land in northern Montana. After they forced the Shoshone to move south, the Blackfeet and Gros Ventre established their own territory in the Montana Rockies, including the Little Rocky Mountains and Project area.

The Assiniboine are members of the Siouan language family. They split from the Yanktonai Sioux in the mid-seventeenth century and moved west and north from ancestral lands in northern Michigan. Much of their

territory was in Canada, but extended southward into northern Montana. By the 1860s, tribal warfare, disease, and Euro-American pressure had forced the Montana Assiniboine to split; one group allying with the Yanktonai Sioux and the other group with the Gros Ventre (McGinnis 1990). The former alliance (Assiniboine and Sioux) was later settled on the Fort Peck Reservation, and the latter alliance (Assiniboine and Gros Ventre) on the Fort Belknap Indian Reservation.

Beginning in the middle of the 19th Century, the U.S. Government initiated the first of several treaties with the Plains Indians, first to facilitate exploration and trading by delineating tribal territories and discouraging intertribal warfare, and later to open up former tribal lands to settlement for purposes of farming, ranching, and mining. The Fort Laramie Treaty of 1851 gathered all the Plains tribes together and "mapped out the domain of each tribe and obligated each tribe to respect the lands of its neighbors" (Malone and Roeder 1976). The Blackfeet and Gros Ventre were recognized as the occupants of the north central region of Montana, east of the continental divide. The Fort Laramie Treaty served as a catalyst for other treaties including the 1855 Treaty with the Blackfeet, Gros Ventre, Assiniboine, Nez Perce, Flat Head, and Pend d'Orielle (Woods 1981). Stemming from the efforts of Isaac I. Stevens, the 1855 Treaty created a vast Indian Reserve in northern Montana which was shared by Gros Ventre and Assiniboine with the Blackfeet. This Reserve included the Little Rocky Mountains.

In 1887, the Northwest Commissioners negotiated the formation of separate Blackfeet, Fort Belknap, and Fort Peck Reservations. This was in large part based upon Agent W. L. Lincoln's perception that the Indian Reserve established in 1855 was too large for it's Indian proprietors, and pressure from white miners, ranchers, and businessmen to open the northern part of the Reserve to white settlement. The Gros Ventre and Assiniboine insisted that the Little Rocky Mountains remain within their boundaries, and since the initial mining boom in the Little Rocky Mountains had already diminished, the government reluctantly agreed to this condition (Hundley 1985; Foley 1975). Ratified by Congress in 1888, the Treaty set the boundaries for the Fort Belknap Reservation as follows:

> *"Beginning at the point in the middle of the main channel of Milk River, opposite the mouth of Snake Creek; thence due south to a point due west of the western extremity of the Little Rocky Mountains; thence due east to the crest of said mountains at their western extremity, and thence following the southern crest of said mountains to the eastern extremity thereof; thence in a northerly direction in a direct line to a point in the middle of the main channel of Milk River opposite the mouth of Peoples Creek; thence up Milk River, in the middle of the main channel thereof, to the place of beginning." (Kappler, 1904, 1:265 in Woods 1981)*

In return, the Gros Ventre and Assiniboine were to receive $115,000 over a 10-year period to be spent on basic social services, such as health care and education, the erection of new agency buildings, and activities to promote their "civilization" (Berry 1974). The reservation underwent one final reduction in 1896 after gold was discovered in the Little Rocky Mountains. Under the Grinnell Agreement, the tribes ceded 14, 758 acres of land (Act of June 10, 1886, 29 Stat. 321, 350) in the Little Rocky Mountains on the southern end of the reservation for $360,000 in annuities. According to the land commission's report, the ceded tract contained over 40,000 acres of land, although only 14,758 acres (a parcel approximately 7 miles long and 4 miles wide) were actually purchased by the government (Deaver and Kooistra 1992). Members of Fort Belknap retain strong concerns about the Grinnell Agreement since (a) they feel that the Indians were coerced and intimidated into signing, (b) the vote to sell was split along tribal lines with the Gros Ventre generally opposed and the Assiniboine generally for, and (c) the understanding that they sold the mining rights, but not the right to the other natural and cultural resources in the Little Rocky Mountains (Deaver and Kooistra 1992; Strahn 1992, 1993). Representatives of Fort Belknap are particularly concerned about water and timber rights which they claim were not surrendered under terms of the Agreement. They also claim that funds meant as payment under terms of the Grinnell Agreement were embezzled on two occasions by government agents.

As a direct result of these and related concerns, the Fort Belknap Community Council passed at least four resolutions petitioning the Department of the Interior, Bureau of Indian Affairs to return the Little Rocky Mountains which were withdrawn when gold was discovered. Resolution 84-73 also states that:

> *"parts of the Little Rocky Mountains have traditionally been held as sacred grounds and have even today special religious and historical meaning to the Fort Belknap Indian Community justifying a return of these lands to the Fort Belknap Indian Community."*

This Resolution, dated September 14, 1973 was drafted at a time when gold mining was at a virtual standstill in the Little Rocky Mountains.

Spiritual and Physical Characteristics of the Little Rocky Mountains

Prior to the exploration and occupation of northern Montana by Euro-Americans, the Little Rocky Mountains were a place of particular importance to the Native Tribes of the Northern Plains. Due to their topography, climate, and location, they provided a unique habitat for subsistence, social, and religious activities. In addition to the Gros Ventre and Assiniboine, a number of other plains tribes used the Little Rocky Mountains for these same activities. Included were the Sioux, Chippewa-Cree, Blackfeet, and Crow.

Early travel accounts lack specific reference to the Little Rocky Mountains, or "Island Mountains" as they were known to the native inhabitants of the area, although visitors to the Fort Belknap area just after the turn of the century note the use of the area for religious activities. Both groups retain fasting, prayer, and the vision quest as primary individual rites. In particular, accounts of Gros Ventre ceremonies include the Feathered Pipe, Flat Pipe, and Sacrifice Lodge (Sundance). The most important group ceremonies for the Assiniboine were the Sundance and the Horse Dance. Vision Questing is described as are paraphernalia and plants used by the Gros Ventre and the Assiniboine for ceremonial purposes. The diary and accounts of John Galen Carter, for example, detail the use of red, green, and yellow cloth, a cottonwood center pole, sweetgrass, willow branches, chokecherry bush, eagle feathers and body paints as some of the accessories of the Sundance celebration (Carter 1906-1907 cited in Deaver and Koistra 1992)

Interviews with contemporary Gros Ventre and Assiniboine conducted by Deaver and Kooistra (1992) and Derek Strahn (1992, 1993) also document use of the Little Rocky Mountains during the 1800s and 1900s. Citing oral history interviews with Assiniboine and Gros Ventre at Fort Belknap and literature sources, Strahn notes that small autonomous bands got together in the Little Rocky Mountains during the winter where food, water, and other necessary resources were readily available. During the summer, complex social activities were conducted here by a number of different tribes (Strahn 1993). In 1875, large numbers of Sioux held a grass dance on the eastern slopes of the Little Rocky Mountains and the Gros Ventre held their Old Man's Dance in approximately the same location four years later. This was also an important place for religious activities where supernatural knowledge and assistance was petitioned through prayers, offerings, fasting, and sacred dances. Annual Sundances were held here because they afforded the tribes a place to gather collectively and contained all the necessary natural resources to construct the lodge and undertake the ceremony. As such, "as a natural storehouse, marketplace, battleground and sacred shrine, the Little Rocky Mountains were, quite literally, a center of tribal being on the northwestern plains." (Strahn 1993)

The affected environment for the Little Rocky Mountains includes both its spiritual and physical characteristics which are traditionally seen as inseparable. The Little Rocky Mountains are one of a set of island mountain ranges recognized as the lodges/homes of the spirits, which are inhabited by eagles (spirit messengers), and contain various peaks (spirit lodges) symbolizing tipis in a Native American camp. The mountains are currently viewed as one of the last refuges where traditionalists can practice spiritual activities such as prayer, fasting, and making offerings. The area is the main watershed for the Fort Belknap communities. Warm water springs are exploited for their healing powers and are often chosen as sweatlodge locations by the Gros Ventre and Assiniboine. In addition, resource procurement was and continues to be an important activity in the Little Rocky Mountains.

Early ethnographers conducting research at Fort Belknap around the turn of the century also documented use of the Little Rocky Mountains for fasting and plant gathering. Kroeber (1908) describes Gros Ventre fasting in the hills and high places up on mountains to receive powers or become doctors and provides a list of thirty-five plants gathered for medicinal purposes. Lowie describes similar practices (Deaver and Kooistra 1992).

The Gros Ventre and Assiniboine have historically and continue today to gather and use portable resources from the Little Rocky Mountains. Deaver and Kooistra (1992), Flemmer (1990,1991), McConnell (1990) and others have described and documented the past and present importance of resource procurement. Included are the use of trees, shrubs, plants, grasses, animals and animal products, fossil remains, and minerals for domestic, food, medicinal, and ceremonial purposes. Virgil McConnell testified at the public hearings in Lodgepole on April 15, 1993, that there are over 100 plants gathered in the Little Rocky Mountains. Other Fort Belknap tribal members also testified to the importance of resource procurement in the Little Rocky Mountains. Deaver and Kooistra provide a list of 41

grass, plant, shrub, and tree resources (1992), many of which have multiple uses. Thirty of these resources are used for medicinal purposes, 15 for ceremonial purposes, 5 have domestic uses, and 2 are used for food. Trees, which themselves are sacred, provide fuel and building material, and have been used historically for tipi poles (lodgepole pine), sweatlodges (willow), and Sundance lodges (cottonwood center pole). Sweet pine and juniper are used as well. The area is also used for hunting, fishing, and domestic animal browsing. Primary plants include sweetgrass, sages, larb, peppermint, prickly pear, rose roots, cherry bark, chokecherries, and certain funguses.

Culwell et al. (1990) include a section on ethnobotany in their study of vegetation resources conducted for the proposed mine expansion. They note that the Little Rocky Mountains have historically been and are currently a source of plant materials for ethnobotanical uses, that the mountains provide a variety of species associated only with isolated mountain or forest grassland ecotones like the Little Rocky Mountains, and that the relatively small size of the range situated within a prairie setting provides an extensive list of useful plants within a small geographical area (1990). They identify 428 species of grasses, plants, forbs, shrubs, and trees within the Area of Potential Effect (APE) defined for vegetation resources for the project. They note that ethnobotanical use is documented for 200 of these species based upon research conducted in similar areas such as the Bear Paw Mountains, Cypress Hills, Sweetgrass Hills, Judith Mountains, Moccasin Mountains, and others. These species can reasonably be expected to occur throughout the Little Rocky Mountain range. Ethnobotanical studies have not been conducted for the Little Rocky Mountains. Of the 41 vegetal resources identified by Deaver and Kooistra, however, 25 (64 percent) are included by the Culwell et al. study as illustrated in Table 3.12-2. (This number would undoubtedly increase if the variation in scientific and common names could be accounted for.)

There has always been a preference for resources procured from the mountains since a great variety of species can be gathered in a fairly restricted geographical area and they are considered more potent than their counterparts gathered from lower elevations. Flemmer (1991) notes that currently this preference includes the lack of dust along with agricultural chemical contamination prevalent at the lower altitudes. McConnell (1990) notes that Native Americans come from all over, including Canada, to gather plants in the Little Rocky Mountains. For the Fort Peck Assiniboine, the Little Rocky Mountains are the closest source of sweetgrass necessary for ritual purification smudging ceremonies. A wide variety of birds are reported in the area including several types of hawks and golden eagles which are spiritually significant birds to both groups.

The Madison Limestones, which form a series of near vertical cliffs that encircle the Little Rocky Mountains, provide a material source for stone tool manufacture. The limestones form caves, many with Native American rock art, as well as crevasses, many of which contain burials respected and revered by the people of Fort Belknap. Fossils with traditional cultural uses include ammonites or "buffalo stones" and belemnites (used by prehistoric groups for ornaments and fetishes), as well as crinoid stars (used by modern Sundance leaders for rattles). A white clay substance (probably bentonite) is used by the Gros Ventre (known as the White Clay People) for staining their clothes and, today, to prepare hides. The Gros Ventre collect red and yellow paint pigments in the Little Rocky Mountains for use in a face painting rite. Rocks, especially granite, are also collected in the Little Rocky Mountains for use in the sweatlodge. Rocks are assigned spirits and are, in general, respected.

3.12.4.4 <u>Inventory</u>

Approximately 15 percent of the Little Rocky Mountains study area used for the ethnographic study has been archaeologically surveyed. A total of 35 prehistoric sites has been recorded in the Little Rocky Mountains, 16 of which are stone ring (tipi ring) sites found on the margins of the mountains. Remaining sites include five lithic scatters, three campsites, two rock art sites, one cairn, one bison kill site, and one set of vision quest structures. These sites have not been identified with a particular historic Native American group. Four cave sites with rock art near the southern portion of the study area have been identified. Several vision quest structures, many used within the past 20 years, have also been reported.

Numerous individual prehistoric, ethnographic, ethnohistoric, and historic sites were identified during the Deaver and Kooistra study (1992). Those sites with spiritual characteristics are the primary focus of this inventory. Six general site types with such characteristics were either documented or can be expected to occur in the Little Rocky Mountains. These are vision quest sites, anthropomorphic rock features, rock art sites, burials, battlefields, and camps containing special purpose structures such as Sundance lodges, buffalo corrals, and dance grounds.

Deaver and Kooistra (1992) recommend two groups of vision quest sites as eligible for nomination to the

TABLE 3.12-2
ETHNOGRAPHIC CULTURAL RESOURCES:
ETHNOBOTANY IN THE LITTLE ROCKY MOUNTAIN STUDY AREA

Deaver & Kooistra 1992			Culwell et al. 1990	
Scientific Name	**Common Name**	**Native Uses**	***Scientific Name***	**Common Name**
Lewisia rediviva	Bitterroot	Medicine		Absent
	Blackroot	Medicine		Absent
Symphoricarpos albus	Buckbrush	Medicine	*Symphoricarpos albus*	Common snowberry
Vaccinium spp.	Blueberries	Used to feed spirits during sweat		Absent
Opuntia fragilis	Cactus (Prickly pear)	Used as binder in ceremonial paint	*Opuntia polyacantha*	Plains pricklypear
Prunus emarginata	Cherry Bark	Medicine		Absent
Prunus virginiana	Chokecherry	Medicine, food	*Prunus virginiana*	Common chokecherry
Glycyrrhiza lepidota	Cocklebur	Medicine	*Glycyrrhiza lepidota*	American licorice
Populus spp.	Cottonwood	Juice used for medicine	*Populus angustifolia*	Narrow leaf cottonwood
	Cottonwood	Center pole in sundance	*Populus angustifolia*	Narrow leaf cottonwood
Juniperus horizontalis	Creeping juniper	Diarrhea medicine	*Juniperus horizontalis*	Creeping juniper
Unknown	Flax Seed	Poultice for flu	*Linum lewisii*	(Blue flax)
Melampsorella elatina	Fungus	Medicine		Absent
Parmelia spp.	Green Lichen	Medicine		Absent
Grindelia squarrosa	Gumweed	Medicine	*Grindelia squarrosa*	Curlycup gumweed
Equisetum hyemale	Horsetail	Medicine for kidneys	*Equisetum hyemale; E. arvense; E. laevigatum; E. variegatum*	Common scouring rush, horsetail
Juniperus spp.	Juniper	Berries used for offerings	*Juniperus scopulorum*	Rocky Mountain juniper
	Juniper Berries	Medicine for asthma	*Juniperus scopulorum*	Rocky Mountain juniper

TABLE 3.12-2 - ETHNOGRAPHIC CULTURAL RESOURCES (Continued)

Deaver & Kooistra 1992			Culwell et al. 1990	
Scientific Name	Common Name	Native Uses	*Scientific Name*	Common Name
Arctostaphylos uva-ursi	Larb	Tobacco	*Arctostaphylos uva-ursi*	Kinnikinnick
	Larb	Mixed with tobacco to make offerings	*Arctostaphylos uva-ursi*	Kinnikinnick
	Larb	Pipe plant	*Arctostaphylos uva-ursi*	Kinnikinnick
Pinus contorta	Lodgepole	Ceremonial	*Pinus contorta*	Lodgepole pine
Asclepias spp.	Milkweed	For the curing of warts		Absent
	Oregon grapes	Roots boiled to produce yellow paint for sundance and doctoring	*(Mahonia repens)*	Creeping Oregon grapes
	Oregon grapes	Medicine		Creeping Oregon grapes
Mentha arvensis L.	Peppermint	Ceremonial, medicinal	*Mentha arvensis*	Field mint
	Peppermint	For fevers	*Mentha arvensis*	Field mint
	Peppermint	Pipe plant	*Mentha arvensis*	Field mint
	Peppermint	Teas	*Mentha arvensis*	Field mint
	Peppermint	Medicine	*Mentha arvensis*	Field mint
	Peppermint	Tea	*Mentha arvensis*	Field mint
Chenopodium rubrum	Pig weed	Used as medicine in North Dakota		Absent
(Not provided)	Rasberry Roots	For fevers	*(Rubus spp.)*	Red raspberry
Cornus stolonifera	Red Willow	Tobacco	*Cornus stolonifera*	Red-osier dogwood
	Red Willow	Skinned and baked for white powder	*Cornus stolonifera*	Red-osier dogwood
	Red Willow	Pipe tobacco	*Cornus stolonifera*	Red-osier dogwood

TABLE 3.12-2 - ETHNOGRAPHIC CULTURAL RESOURCES
(Continued)

Deaver & Kooistra 1992			Culwell et al. 1990	
Scientific Name	Common Name	Native Uses	*Scientific Name*	Common Name
	Red Willow	Pipe plant	*Cornus stolonifera*	Red-osier dogwood
	Red Willow	Medicine	*Cornus stolonifera*	Red-osier dogwood
Rosa spp.	Rose Roots	Medicine	*Rosa acicularis; R. arkansana; R. woodsii*	Prickly, prairie & wood's rose
Artemisia ludoviciana	Sage	Used in vision quest	*Artemisia cana; A. tridentata*	Silver sagebrush/big sagebrush
	Sage	Pipe plant	*Artemisia cana; A. tridentata*	Silver sagebrush/big sagebrush
	Sage	A tea for colds	*Artemisia cana; A. tridentata*	Silver sagebrush/big sagebrush
	Sage (White)	Ceremonial	*Artemisia cana; A. tridentata*	Silver sagebrush/big sagebrush
	Sage	Ceremonial at the sundance	*Artemisia cana; A. tridentata*	Silver sagebrush/big sagebrush
	Sage	Medicine	*Artemisia cana; A. tridentata*	Silver sagebrush/big sagebrush
	Sage	Burials	*Artemisia cana; A. tridentata*	Silver sagebrush/big sagebrush
	Sage	Medicine	*Artemisia cana; A. tridentata*	Silver sagebrush/big sagebrush
Yucca glauca	Soapweed, Yucca	Medicine, domestic use	*Yucca glauca*	Soapwell yucca
Hierochloe odorata	Sweetgrass	Ceremonial		Absent
	Sweetgrass	Medicine		Absent
	Sweetgrass	Incense		Absent

TABLE 3.12-2 - ETHNOGRAPHIC CULTURAL RESOURCES (Concluded)

Deaver & Kooistra 1992			Culwell et al. 1990	
Scientific Name	Common Name	Native Uses	*Scientific Name*	Common Name
	Sweetgrass	Used as smudge and as tea in ceremonies		Absent
Abies lasiocarpa	Sweet Pine	For a smudge ceremony		Absent
	Sweet Pine	Ceremonial		Absent
	Sweet Pine	Ceremonial		Absent
Evernia vulpina	Tree Lichen	A natural yellow dye		Absent
	Tree, lightning struck	Pitch in scar used for doctoring		Absent
Unknown	Wick-we(in Cree-rat root)	Ceremonial, medicinal		Absent
Daucus spp.	Wild carrot	Medicine		Absent
Lomatium orientale	Wild parsley	Pipe Plant	*Lomatium cous; L. foeniculaceum; L. macrocarpum; L. triternatum*	Several types of lomatiums and desert parsley
(Not provided)	Wild rhubarb	Medicine		Absent
Salix spp.	Willow	Used to construct sweat lodges	*Salix bebbiana; S. exigua; S. lutea; S. scouleriana*	Bebb, sandbar, yellow, scouler willow
	Willow	Ceremonial	*Salix bebbiana; S. exigua; S. lutea; S. scouleriana*	Bebb, sandbar, yellow, scouler willow
Pinus spp.	Yellow pine	Domestic use	*Pinus contorta; P. ponderosa*	Lodgepole and ponderosa

National Register as TCPs. Eagle Child Mountain District, located approximately three and one-half miles west of the proposed mine expansion, contains a number of vision quest structures. Beaver Mountain Vision Quest Sites, located approximately one mile north of the proposed mine expansion, consist of several structures and include recent cloth offerings. Both sites are recommended as eligible under criterion (a) of 36 CFR 60.4 for their association with a major theme in tribal history, vision questing. The Beaver Mountain sites are also considered significant under criterion (c), due to the presence of structures representative of those types used historically and currently by Fort Belknap residents.

Six areas are identified as potential TCPs (i.e., areas that are thought to contain TCPs but that need further investigation to document the presence and importance of sites), including Chief Red Whip Battlefield Site, Mission/Monument Peak, Coming Day Butte, Gold Bug Butte, Thornhill Butte, and Coburn Butte. Thornhill and Coburn buttes and the Chief Red Whip Battlefield Site are located outside the APE.

The ethnographic study also identifies nine general areas of "intangible spiritual values" or areas of modern cultural resources (less than 50 years old) that are reportedly associated with traditional cultural practices. These resources are considered under AIRFA rather than their National Register eligibility. The people of the Fort Belknap Indian Community appear to have strong spiritual attachments to these and other places regardless of existing physical remains. These resources include Mission Canyon, Travois Butte, Big Warm Creek, Bear Gulch, Indian Peak, Old Scraggy Peak, Silver Peak, Beaver Creek Area, and Mouse Canyon and Butte.

Classified according to primary site activity, the selected inventory of forty-one (41) Native American cultural resources provided in Table 3.12-3 includes 25 sites associated with Religion and Ritual, 4 rock art sites, 2 burial places, 2 healing places, 2 sundance sites, 2 resource procurement sites, 2 historic events, 1 flat pipe offering site, and 1 contemporary Pow Wow site. Most of these resources are, of course, multiple activity locations, e.g., a religion and ritual location may include vision questing and fasting as well as resource procurement. The emphasis is on vision quest sites and the locations are general. Deaver and Kooistra note on their confidential map of several vision questing and other sacred areas that, "Boundaries are indeterminate at this point in time. Further survey and consultation is needed to determine boundaries" (Pegasus Gold Corporation 1990). Still, the inventory represents the kinds of sites and associated values present within the Little Rocky Mountains and is adequate for the present analysis and assessment.

With several exceptions, specific resource procurement areas could not be included in the inventory due to lack of information on particular locations. It is safe to assume, however, that many of the resources discussed above are currently gathered, are an important part of contemporary Indian culture, and occur throughout the Little Rocky Mountains and the APE. A single Resource Procurement category is included in the inventory to recognize this activity. Similarly, only one specific burial location was identified, although the use of the Little Rocky Mountains for mortuary practices is well documented. A single Burial category is included in the inventory to recognize this activity as well.

3.12.4.5 The Little Rocky Mountains as a Traditional Cultural Property District

Certain segments of the Fort Belknap Indian Community, including Red Thunder, Inc. and Island Mountain Protectors, have maintained for some time that the entire Little Rocky Mountains are eligible for listing in the National Register of Historic Places, and have sent letters to the BLM, the BIA, and the Montana SHPO in this regard. They have also stated that additional, comprehensive studies of the significance of the entire Little Rocky Mountains to Native Americans are necessary, and that Native Americans should conduct these studies.

Deaver and Kooistra (1992) applied the significance criteria outlined in National Register Bulletin 38 to evaluate the entire Little Rocky Mountains as a potential National Register district. Interview data compiled during the ethnographic study indicate that an identifiable group of traditionalists regard the Little Rocky Mountains as significant in tribal history, particularly as a fasting area that has been used to help the Gros Ventre and Assiniboine in important decision-making processes. The integrity of this relationship is apparently intact, as the interview data indicate a continuing tie between the people of Fort Belknap and the Little Rocky Mountains.

Deaver and Kooistra (1992), however, raised concerns regarding the integrity of condition of the area, based on two factors: (1) not enough survey data exist to demonstrate that the vision questing properties present at sites in the Little Rocky Mountains are recognizable to Fort Belknap traditionalists, and (2) with few

TABLE 3.12-3
SELECTED INVENTORY OF NATIVE AMERICAN SITES WITHIN THE LITTLE ROCKY MOUNTAINS AND AREA OF POTENTIAL EFFECT

Site No.	Site Type	Site Activity	Site Location USGS 7.5' Quadrangle	Source of Identification
01	**Religion and Ritual**	Vision Questing Sacred Sites	Zortman	Deaver & Kooistra 1992 Flemmer 1991
02	**Religion and Ritual**	Vision Questing Fasting Burials	Zortman	Deaver & Kooistra 1992 Flemmer 1990, 1991 McConnell 1990
03	**Religion and Ritual**	Vision Questing Fasting Burials	Zortman	Deaver & Kooistra 1992 Flemmer 1990, 1991 McConnell 1990
04	**Religion and Ritual**	Fasting Plant Gathering Possible Burials	Zortman	Deaver & Kooistra 1992 Flemmer 1990, 1991 McConnell 1990
05	**Religion and Ritual**	Fasting Sacred Sites	Zortman	Deaver & Kooistra 1992
06	**Religion and Ritual**	Vision Questing Fasting Burials	Zortman	Deaver & Kooistra 1992 Flemmer 1990, 1991 McConnell 1990
07	**Religion and Ritual**	Vision Questing	Zortman	Deaver & Kooistra 1992 Flemmer 1990
08	**Religion and Ritual**	Vision Questing	Zortman	Deaver & Kooistra 1992 Flemmer 1991 McConnell 1990
09	**Religion and Ritual**	Vision Questing Coming Day Place Fasting	Bear Mountain	Deaver & Kooistra 1992 Flemmer 1991 McConnell 1990
10	**Religion and Ritual**	Vision Questing Fasting Sacred/Spiritual Place	Hays & Zortman	Deaver & Kooistra 1992 Flemmer 1990, 1991 McConnell 1990

TABLE 3.12-3 - SELECTED INVENTORY OF ETHNOGRAPHIC SITES (Continued)

Site No.	Site Type	Site Activity	Site Location USGS 7.5' Quadrangle	Source of Identification
11	**Religion and Ritual**	Vision Questing Fasting Offerings Sacred Sites	Hays	Deaver & Kooistra 1992 Flemmer 1990, 1991 McConnell 1990
12	**Religion and Ritual**	Fasting Burials Prehistoric Camps	Hays	Deaver & Kooistra 1992 Flemmer 1990, 1991 McConnell 1990
13	**Religion and Ritual**	Vision Questing Offerings	Hays	Deaver & Kooistra 1992 McConnell 1990 Flemmer 1990
14	**Religion and Ritual**	Vision Questing Offerings Sacred Sites	Bear Mountain	Deaver & Kooistra 1992 Flemmer 1991 McConnell 1990
15	**Religion and Ritual**	Vision Questing	Hays & Crazy Man Coulee	Deaver & Kooistra 1992 McConnell 1990
16	**Religion and Ritual**	Vision Questing Fasting Offerings	Bear Mountain	Deaver & Kooistra 1992 Flemmer 1991 McConnell 1990
17	**Religion and Ritual**	Vision Questing Rock Art Burials	DY Junction	Deaver & Kooistra 1992
18	**Religion and Ritual**	Vision Questing	Coburn Butte	Deaver & Kooistra 1992
19	**Religion and Ritual**	Fasting Sundances	Lodgepole	Deaver & Kooistra 1992
20	**Religion and Ritual**	Vision Questing	Lodgepole	Deaver & Kooistra 1992
21	**Religion and Ritual**	Offering Area	Hays	Flemmer 1990, 1991
22	**Religion and Ritual**	Fasting	Hays and Zortman	McConnell 1990

TABLE 3.12-3 - SELECTED INVENTORY OF ETHNOGRAPHIC SITES (Continued)

Site No.	Site Type	Site Activity	Site Location USGS 7.5' Quadrangle	Source of Identification
23	Religion and Ritual	Vision Questing	Zortman	Flemmer 1990
24	Religion and Ritual	Vision Questing	Zortman	Flemmer 1990
25	Religion and Ritual	Vision Questing	Zortman	Flemmer 1990
26	Rock Art	Prehistoric Site	Zortman	Flemmer 1991 Fredlund 1969
27	Rock Art	Prehistoric Site	Zortman	Flemmer 1991 Stickley 1969
28	Rock Art	Prehistoric Site	Zortman	Flemmer 1991 Barnier 1969
29	Rock Art	Prehistoric Site	Zortman	Flemmer 1991 Conner 1967
30	Burial	Burial	Hays	Flemmer 1990
31	Burial	Burial	Little Rocky Mountains	Deaver & Kooistra 1992
32	Healing	Medicinal Spring Curative Powers	Hays	Flemmer 1990
33	Healing	Healing Waters Modern Sweatlodges	Ball Coulee	Deaver & Kooistra 1992
34	Sundance	Sundance Site Ceremonial Plant Gathering Medicinal Plant Gathering	Hays	Deaver & Kooistra 1992 Flemmer 1991 McConnell 1990
35	Sundance	Sundance Grounds	Hays	Flemmer 1990
36	Resource Procurement	Ritual and Fossil Gathering Camping Area Bison Kill Offerings	Bear Mountain	Deaver & Kooistra 1992

TABLE 3.12-3 - SELECTED INVENTORY OF ETHNOGRAPHIC SITES (Concluded)

Site No.	Site Type	Site Activity	Site Location USGS 7.5' Quadrangle	Source of Identification
37	**Resource Procurement**	Plant Resources Mineral Resources Animal Resources	Little Rocky Mountains	Deaver & Kooistra 1992 Flemmer 1991 McConnell 1990 Lutwell et. al 1990
38	**Historic Event**	Historic Battle Site	Hays	Deaver & Kooistra 1992 Flemmer 1990, 1991
39	**Historic Event**	Coming Day's Route to Escape Epidemic	Hays, Zortman, Lodgepole	Flemmer 1991
40	**Pipe Offering**	Flat Pipe Offering	Hays	Flemmer 1990
41	**Powwow**	Pow Wow Grounds	Hays	Flemmer 1990, 1991

exceptions, interview data could not address whether or not modern and historic impacts have altered portions of the Little Rocky Mountains to the point where integrity of condition has been significantly diminished or destroyed.

A joint position on National Register eligibility was developed by the Fort Belknap Community Council, the Bureau of Indian Affairs, and the Bureau of Land Management who also entered into a Memorandum of Understanding in June of 1994 to form a special task force to further study the potential of the Little Rocky Mountains as a Historic District. The eligibility position paraphrases Bulletin 38 (Parker and King 1990) in stating that the Little Rocky Mountains are eligible as a TCP because they are:

> a location associated with the traditional beliefs of a Native American groups about its origins, culture history, and the nature of the world; are a location where Native American religious practitioners have historically gone, and are known to go today to perform ceremonial activities in accordance with traditional cultural rules of practice; and are a location where an identifiable community has carried out economic, artistic, and other cultural practices important in maintaining its historical identity.

The BLM and the Montana SHPO have concurred that the district is eligible under criterion (a) of 36 CFR 60.4, "associated with events that have made a significant contribution to the broad patterns of our history." It was also recognized, however, that other sites and smaller districts within the Little Rocky Mountains District may be individually eligible under other criterion. The task force also recognized that the boundaries were "working boundaries" and could be amended at a later date dependent on additional information and consultation. These boundaries encompass the APE.

3.12.4.6 Mining History in the Little Rocky Mountains and Traditional Cultural Practices

In order to establish an adequate baseline setting for the impact assessment which follows in Chapter 4.0, it is necessary to briefly review the history of mining in the Little Rocky Mountains and the effects of mining on the culture and society of the Gros Ventre and Assiniboine tribes at Fort Belknap.

During the early 1880s, prior to the formation of the Fort Belknap Indian Reservation, gold was discovered on the southern slopes of the Little Rocky Mountains and 2,000 miners stampeded across reservation boundaries, illegally establishing a mining district and a recorder to register their claims (Burlingame and Toole 1957). Coupled with the loss of the buffalo herds and increased settlement throughout Montana and the west, the relative independence and isolation of the Fort Belknap Gros Ventre and Assiniboine came to an end. Within ten years of the Grinnell Agreement, the Little Rocky Mountains mining district became the largest gold producer in Montana at that time. With the introduction of improved mining technology, machinery, and techniques, which included the cyanide leaching process, the mines remained productive until 1918 when a wartime economy slowed the pace. A brief revival in the 1930s was followed by a devastating forest fire in 1936 which in effect greatly reduced the pace of mining company operations (Strahn 1993).

U.S. Government policies of forced assimilation, aggressive religious proselytizing, and exposure to new ideas and technologies combined to work against the practice of traditional cultural practices during the late 1800s and continuing into the 20th Century. The religious effort was spearheaded at Fort Belknap by the establishment of a Mission and industrial school in the Little Rocky Mountains where Gros Ventre and Assiniboine children were physically removed and forcibly alienated from the traditional lifestyle of their parents and elders. The Mission, boarding schools, and outside influences replaced traditional forms of socialization, and tribal elders ceased to participate in tribal political and religious functions (Kelley 1894; Hays 1896). The path to ritual authority was questioned, and many elders who possessed knowledge of native doctoring, sacred songs, and religious protocols died without passing on their knowledge to their christianized children (Tucker 1981 in Strahn 1993). Reportedly, pow wows, naming ceremonies, giveaways, and social dances replaced the sacred rituals once practiced in the Little Rocky Mountains.

The Gros Ventre and Assiniboine populations dropped from a high of 1,700 in 1882 to a low of 1,145 in 1895, a reduction of 33 percent in a 13-year period. This may be attributed to a number of factors including poverty and illness, but certainly includes as well the loss of their traditional resource base. Agent J. M. Kelley noted that in 1894 the Gros Ventre lived near the Little Rocky Mountains while the Assiniboine resided along Milk River, but were dissatisfied and "gradually removing to more favored localities at the foot of the mountains,

where wood is abundant and plentiful supply of cool mountain water always at hand" (Kelley 1894).

At the same time, the transformation of the Little Rocky Mountains from a natural landscape where traditional culture was practiced to an industrial landscape valued only for the exploitation of its mineral deposits, served to change native perceptions of the area.

> *"The pristine abundance, solitude and aesthetic beauty that once inspired the reverence of the Assiniboines and Gros Ventres rapidly deteriorated after 1895. Moreover, the traditional status once obtained through hunting, gathering, religious rituals and powers obtained through vision questing in the mountains was, with the ongoing development of mining in the area, nearly impossible to obtain. Alienated from their cultural landscape and prohibited from obtaining these customary means of power elsewhere, the reservation's younger generation struggled to find new places and ways in which to gain prestige within their respective societies (Strahn 1993)."*

Some of the ethnographers who conducted research on the reservation from the 1930s focused on the negative aspects of the social and psychological processes involved in the face of rapid change, or acculturation, which was academically popular at the time. Rodnick (1938), for example, who assuming that the Indians passively accepted changes introduced from the outside, noted that "the disintegration of culture of the old days has been most amazingly rapid" and Dusenberry (1960) observed that both groups "seem to have lost more of their aboriginal culture--more in fact than one finds on other reservations today." While the acculturation approach yielded a wealth of information about the processes of change, some of its students saw the recipients of change blindly accepting the new and throwing out the old. Other investigators, however, have documented the selective nature of change and the ability for different cultural traditions, the old and the new, to function side by side in the same populations (Woods 1975).

Several scholars have reported the continued practice of traditional ways in the Little Rocky Mountains documenting sacrifice alone in the hills, fasting, and plant gathering (Cooper 1957), and, fasting in the hills during mourning, and experiencing visions of supernatural significance in the hills (Flannery 1953). Verne Ray disputes the notion of rapid acculturation and cultural disintegration, noting that the Gros Ventre have maintained a unique ethnic identity, different from Euro-American culture even though they have adopted material items of the Euro-American tradition (Ray 1975). Later researchers have focused on how the Indians have reacted and adjusted to change (Miller 1987) and the differing viewpoints of elderly Indians and younger Indians trying to learn and live in a traditional way (Fowler 1984,1987).

The literature published prior to 1988 lacks many specific statements about the sacredness of the Little Rocky Mountains and generally fails to identify specific vision quest locations. Deaver and Kooistra (1992) explain this apparent contradiction according to a combination of four factors: (1) vision questing is intensely personal and the experience and location are not to be discussed with others; (2) the religious practitioners and elders interviewed during the earlier studies withheld information from others not only because it was sacred, but because it was discouraged and at times illegal to engage in traditional religious rituals; (3) the Gros Ventre and Assiniboine believe that all places have spiritual qualities so that the identification of specific sacred places may be seen as nonsensical and arbitrary; and (4) researchers of the time were not particularly interested in particular localities. Studies focusing on the specific identification of sacred places and other localities are relatively recent, and are in large part, a response to federal agency needs to comply with requirements of AIRFA and Section 106 of the NHPA. Importantly, Deaver and Kooistra (1992) also note that the current attempt to document specific traditional cultural properties within the Little Rocky Mountains is a direct response to the intervention of Red Thunder, Inc. to mining Permit Amendment No. 10 filed in 1990.

In more recent times, many writers have noted a strong revival of interest in traditional cultural practices, including the sacrifice lodge (Sundance) and vision questing in the Little Rocky Mountains. Deaver and Kooistra (1990) surmise that this practice has become more common in the last 5-10 years; Flemmer (1990,1991) documents the practice and identifies some locations through interviews and field reconnaissance with tribal members; and Melton (1990,1993) provides similar kinds of information. Strahn (1992) also documents this resurgence of traditionalism, noting a relationship between this and environmental awareness and activism. Individual use of the Little Rocky Mountains for traditional practices was also apparent from the testimony of various tribal members during the public hearings for mine expansion held at Lodgepole on April 15-16, 1993 and in meetings and conversations with tribal members undertaken during that same time period (Woods 1993).

Mining in the Little Rocky Mountains can be characterized as heavy during the 1800s through the turn of the century, cyclical from the 1920s through the 1940s and sporadic through 1951. The forest fire in 1936, subsequent loss of terrain to heavy rains in 1937, and a hiatus during World War II contributed to the absence of the intensive mining activities which characterized the earlier periods. After 1951, little serious activity occurred in the Little Rocky Mountains until modern surface-mining operations were initiated in 1979. (See Section 3.12.3.2.)

The consequence of mining operations for vision questing and other traditional activities in the Little Rocky Mountains has been described in an Affidavit by Virgil McConnell, an Assiniboine elder and religious leader:

> *"Fasting Sites in the Little Rocky Mountains prior to the opening of the early mines in the 1800's consisted of many mountains: Gold Bug Butte, Mission Peak, Indian Peak, Silver Peak, Old Scraggy, Bear Mountain, Saddle Butte, Shell Butte (modern names). All of or most of these sites were lost by the mining operations of the 1800's. The start of heap mining in 1978 caused loss of McConnell Mountain, Damon Hill, McMeal Ridge, Monument Peak, all cliffs near the north side of the Little Rocky Mountains between Coming Day Butte and Whitehorse Canyon. At the present time, the people in the Hays area have only Eagle Child Peak and Otter Robe Ridge for fasting. Near Lodgepole, they only have cliffs between Brown Canyon and Kunnyhard Canyon, Coming Day Butte and Travois Butte. Expansion of the existing mines will threaten the remaining few sites. There is a resurgence of interest in traditional religion and the few remaining sites are even in more demand. Loss of fasting sites will take away the ability of local traditional people to practice their religion." (McConnell 1990)*

The onset of the period of modern mining (1979 to 1994) saw a sharp increase in activities which compromised the use of the Little Rocky Mountains for traditional cultural practices at the same time that a revival of interest in such activities was taking place. McConnell notes that a number of sites were "lost" prior to 1979 and others "lost" after 1979 with the initiation of heap leach mining. Prior to 1979, significant physical disturbance had occurred in Montana Gulch, Beaver Creek, Pony Gulch, and mill tailing were deposited in King Creek, Alder Gulch, and Ruby Gulch. Visual and audial disturbance to these and adjacent areas was ongoing. All of these previously disturbed areas are at or near important ethnographic sites. Since 1979, there has been additional physical disturbance to these areas and extensive physical disturbance to Antoine and Shell Buttes (Zortman), and Gold Bug Butte and Mission Peak (Landusky).

It is important to point out, however, that while some of these sites have been physically disturbed and altered, and others rendered less desirable because of the ongoing visual and audial disturbances, some are still in use, and some of those in use are within a mile of the existing operations at Landusky and Zortman. The best information available indicates that favored spiritual locations continue to be used by some individuals, even though they are in the vicinity of the mines. On Mission Peak, for example, there is evidence of recent vision questing on the west side of the peak, away from the mining activities to the east.

Currently however, there is no information available regarding the frequency of this practice or the frequency of vision questing or other cultural practices, such as resource procurement at other places further removed from the mining operations. The past, present, and future use of the Little Rocky Mountains for traditional cultural practices is reinforced by the concurrence determination that the Little Rocky Mountains are eligible for listing on the National Register of Historic Places as a Traditional Cultural Property District.

3.13 AREAS OF CRITICAL ENVIRONMENTAL CONCERN (ACEC)

Areas of Critical Environmental Concern (ACECs) are BLM land units that require special management to protect resource values. Azure Cave and prairie dog towns within the Prairie Dog 7km Complex are two areas that have recently been designated as ACECs by the BLM which may be impacted or are in close proximity to the proposed mine expansions. Three other areas have been nominated for consideration as ACECs, including Little Rocky Mountains, Saddle Butte, and Old Scraggy Peak.

3.13.1 Azure Cave

Azure Cave is designated as an ACEC for its significant geological and biological resources. Azure Cave ACEC contains a relatively large limestone solution cavern (1,580 feet of mapped passage and -220 feet in depth) located approximately 4,800 feet from the proposed mine expansion (see Exhibit 1). Azure Cave has national significance because of its bat hibernaculum values.

The most significant aspect of Azure Cave is its vertebrate biology. Although the population of 300-500 bats is small compared to other caves in the U.S., the bats make it a truly unique cave in Montana and the region (Chester et al. 1979). Azure Cave is currently used by at least three species of bats as a hibernaculum. These are the Townsend's big-eared bat, the little brown bat, and the long-legged myotis (Butts 1993). It has also been used by others such as the big brown bat, the northern long-eared myotis, and may be used by the western small-footed myotis as this species has been previously documented using the cave during late summer and early autumn months (Chester et al. 1979; Howard and Hintzman 1964). Bats reported to use the cave in summer include Northern long-eared myotis, little brown bat and big brown bat (BLM 1991).

Azure Cave contains more speleothems (rock formations) than any other cave in Montana except Lewis & Clark Caverns (Campbell 1978). The lower level has many stalactites and stalagmites, some of which are more than 6 feet long. Cave popcorn and flowstone decorate the walls of the cave. In one room, there is a very large cluster of helectites which may be the best in Montana. Formations are still growing since the cave is active and wet.

Azure Cave and surrounding lands were transferred to the BLM from the National Forest System by Public Land Order No. 3938 on February 23, 1966. This order withdrew 139.41 acres around the entrance to Azure Cave for the protection of public recreation values and the significant cave values and resources it contains. This withdrawn area is the ACEC boundary. The withdrawal removed the land from all forms of appropriation under the public land laws.

Management actions proposed for Azure Cave in the Judith Valley Phillips Resource Management Plan EIS (1992) include:

- Managing the cave to protect bats during critical hibernation periods and to allow specific and general recreation use on a limited basis.
- Preparing an activity plan to determine time periods for cave access and to initiate appropriate management activities to protect bats.
- Continuing the withdrawal from mining claim location.

3.13.2 Prairie Dog 7km Complex

The Prairie Dog 7km Complex ACEC is located south and east of the proposed project. This ACEC includes 12,346 acres of prairie dog towns on BLM land. The nearest delineated prairie dog town is located approximately 8 miles south of the project. This complex is unique because it contains habitat for about 75 wildlife species including burrowing owls, ferruginous hawks, and mountain plover. This area contains a significant amount of high quality habitat for the endangered black-footed ferret. Prairie dogs are essential as the primary prey species for ferrets. The 7km Complex meets USFWS habitat assumptions for ferret management because it encompasses two or more prairie dog towns that are not more than 7 kilometers apart. Black-footed ferret reintroduction plans call for ferrets to be released approximately 40 miles from the project area and ferrets were re-introduced into this complex in 1994.

3.13.3 Saddle Butte

The entire Saddle Butte area has been nominated for consideration as an ACEC due to unique vegetation communities. A savannah community, classified as Douglas Fir/little bluestem, is located on the upper southeast slopes of Saddle Butte. This plant association was previously identified as a rare community by the

Montana National Heritage Program (MNHP). Recently, the MNHP reevaluated this association and removed it from the MNHP State Classification list (Cooper 1995). This area is currently undergoing evaluation by the BLM to determine if it qualifies for further consideration as a potential ACEC.

3.13.4 Old Scraggy Peak

Old Scraggy Peak was nominated for consideration as an ACEC for Native American cultural and historic values. This area is currently undergoing evaluation by the BLM to determine if it qualifies for further consideration as a potential ACEC.

3.13.5 Little Rocky Mountains

The entire Little Rocky Mountains area has been nominated for consideration as an ACEC because of its Native American cultural and historic values. This area is currently undergoing evaluation by the BLM to determine if it qualifies for further consideration as a potential ACEC.

3.14 HAZARDOUS MATERIALS

3.14.1 Introduction

A variety of potentially hazardous materials have been used in the mining, ore processing, and mine reclamation activities at the Zortman and Landusky mines. The rate of use for these materials has varied over the years, and some have replaced others to increase operational efficiency or to accommodate operational modifications.

The following sections describe the use, storage, and consumption of these materials at the mines as well as disposal of various types of wastes. The transportation of hazardous materials is addressed in Section 3.11. In addition, a history of accidental spills and releases of hazardous materials is presented, along with a description of emergency response and spill contingency planning that has been carried out to address potential spills or releases in the future.

3.14.2 Historic Use of Hazardous Materials (Pre-1979)

In general, very little information is available concerning hazardous materials use by historic mining operations in the Little Rocky Mountains prior to 1979. Sources of information on the history of mining in the Little Rocky Mountains indicate that amalgamation of gold ores was carried out at mills near the historic Gold Bug Mine and near Mill Gulch just above the town of Landusky (Bryant 1953). This process utilized mercury, although the quantities used are unknown. This process was used from 1893 to 1902 and was discontinued in favor of the more effective cyanidation process.

Following the use of mercury amalgamation for gold extraction, cyanide was used extensively at both the Ruby Mill, at the present day Zortman Mine, and at the Alder Gulch Mill for extraction of gold. The Alder Gulch Mill, located west of the present day Zortman Mine, was built in 1903 and only operated until 1908 (Little Rockies Miner 1908). This mill may have been the first to use cyanide for extraction of gold. Cyanide was also used in milling operations at the historic August and Gold Bug Mines in the vicinity of the Kings Creek and Montana Gulch drainages at the present day Landusky Mine (Bryant 1953). The use of cyanide in milling of ores continued sporadically until around 1957. With respect to potential contamination, it is important to note that sampling of tailing in the King Creek drainage revealed no detectable concentrations of cyanide (Muza 1993).

Although it is likely that other hazardous materials, such as gasoline or diesel, may have been used or consumed in the project area prior to 1979, no information was found describing such use and little evidence exists today that spills or releases of significance occurred.

3.14.3 Hazardous Materials Use - 1979 to Present

3.14.3.1 Chemical Use, Storage, and Consumption-Zortman Mine

The following is a description of chemicals used at the Zortman Mine from 1979 to the present. Over this time frame, some materials used have been replaced by others. For instance, petroleum-based solvents are no longer used at the mine, having been replaced by a citrus-based solvent substitute. Since the mining of ore ceased at the Zortman Mine in 1990, it is important to note that most of the chemicals presently consumed in the project area are associated with Landusky Mine operations.

The following chemicals have been used for makeup water, ore processing, and the water treatment plant:

Gasoline is used to power the mine's light vehicles. It arrives on site by bulk truck in 500 to 2,000 gallon batches and is off-loaded into a 1,000 gallon aboveground storage tank on a concrete containment pad located behind the ZMI office in the town of Zortman. The estimated annual usage of gasoline is 5,000 gallons at the Zortman Mine.

Diesel Fuel is used to power mine trucks and other heavy equipment. It arrives on site by tanker and is stored in a 1,000 gallon aboveground tank near the Zortman refinery. The diesel tank sits on a steel containment structure. Estimated annual consumption is 1,500 gallons.

Oil and Lubricants are used for lubrication of mine equipment. Oil products include rock drill oil, lubricant oils, hydraulic fluids, engine oils, and transmission fluids. Waste oil is stored in a 200 gallon aboveground tank in the Zortman light vehicle shop on a temporary basis. Waste oil is typically transported by truck to the Landusky Mine, where it is stored in an 8,000 gallon aboveground tank on a concrete containment pad prior to transport off-site. Shipment sizes for these

compounds vary. Annual usage for the Zortman Mine is approximately 1,000 gallons. Prior to 1990, when active mining occurred at the Zortman Mine, a heavy vehicle maintenance garage was operated near the 82 leach pad. Oil and lubricants were stored and used in this garage while it was in operation.

Antifreeze comprised of ethylene glycol is used as engine coolant for the mine fleet. It arrives in bulk trucks in 100 to 1,000 gallon batches and is off-loaded into a 1,500 gallon aboveground tank located on a concrete containment pad adjacent to the diesel fuel and oil tanks at the Landusky Mine. Estimated annual usage by vehicles at the Zortman Mine is 500 gallons. Waste antifreeze is transported to a temporary storage area on containment in the Landusky fuel farm. It is subsequently transported off-site for recycling.

Citrus-Based Solvent is non-hazardous and is used for parts washing. Estimated amount used at the Zortman Mine is 200 gallons per year. A private vendor periodically removes the spent solvent from the mine site and provides new solution.

Sodium Cyanide was used in the past at the Zortman Mine to dissolve the gold and silver in the leaching process. At present, it is only used in the refinery in smaller quantities. The dry sodium cyanide is stored on a concrete curb adjacent to the barren solution pond in the 200 pound barrels it was shipped in. Truck loads are approximately 20 tons. During active mining at the Zortman operation, the estimated quantity of sodium cyanide used per year was 600 to 700 tons. At present, consumption is roughly 40 tons/year.

Lime has been used in the past to control the pH of cyanide solution during the metal extraction process and pH control at the water treatment plant. At present, lime is only used at the water treatment plant. Lime is stored in an enclosed silo on a concrete slab near the processing plant. Lime is shipped to the mine in a tanker trailer carrying about 20 tons. At present, approximately 120 tons per year are consumed at the Zortman Mine water treatment plant.

Hydrochloric Acid (HCl) at a molar concentration of 11 is used to remove scaling on the clarifiers, pump intakes, impellers, spray lines and return lines. It arrives at the site by tanker truck and is off-loaded into a 5,000-gallon double-walled aboveground tank located in a concrete containment structure adjacent to the refinery on the 89 leach pad. It is usually shipped in relatively small quantities, arriving at the site in batches of 1,000 to 5,000 gallons. Approximately 15,000 gallons of HCl are used per year at the Zortman Mine.

Sodium Hydroxide (Caustic Soda) is used in the stripping circuit in the Zortman refinery to aid in desorption of gold and silver from the loaded carbon. The caustic soda is delivered to the mine in a 25 percent solution by a 4,500 gallon tanker truck. The solution is stored adjacent to the refinery in a 5,000 gallon aboveground tank within a 7,200 gallon concrete containment structure. Annual consumption is approximately 5,000 gallons.

Anti-Scalants are used to prevent scaling around the pump intakes and in the spray and return line. Anti-scalants are shipped to the mine site by truck in batches of about 1,000 to 2,000 gallons, and stored at the point of use in aboveground tanks. Approximately 800 gallons of anti-scalant are used per year at the Zortman Mine. Empty anti-scalant bins are returned to the vendor.

Flocculent is presently used at the water treatment plant to help settle sludge out of solution. The flocculent, Nalco 7852, is an aqueous solution of a polyquaternary amine used at the treatment plant. It is shipped in recyclable, one-ton metal containers and is stored in the treatment plant on a concrete floor. Annual consumption at the Zortman Mine is 100 gallons. Empty containers are returned to the vendor.

Hydrogen Peroxide (H_2O_2) is used at the end of leach pad life to destroy cyanide in heap rinsate solution if natural degradation of cyanide needs to be accelerated. Hydrogen peroxide is shipped to the mine in double-walled tanker trucks which unload into a double-walled aboveground storage tank on the 82 leach pad. An estimated 10,000 to 20,000 gallons of 70 percent hydrogen peroxide may be required, depending on amount of natural degradation of cyanide compounds. Approximately 550 gallons of H_2O_2 are kept on hand at the mine.

Calcium Hypochlorite is used on a very infrequent basis to neutralize cyanide solution which may have leaked or spilled out of containment systems. This material is stored on the 82 leach pad in the shipping containers. Calcium hypochlorite is shipped in 100 pound containers. Annual usage is determined by the event and magnitude of spills requiring neutralization.

Laboratory Reagents are used in the Zortman Assay Lab in the town of Zortman for analyzing the metal content of ore samples. Those reagents are used in small quantities and are stored on concrete containment within the lab building.

3.14.3.2 Waste Disposal-Zortman Mine

Solid Waste from the mine, such as paper waste from the mine office, is disposed in accordance with the rules and regulations of the Waste Management Division of Montana Department of Health and Environmental Sciences. Municipal Class II solid waste is compacted and transported to a sanitary landfill in Fergus County for disposal. Inert, Class III wastes such as wood and concrete are occasionally buried on-site in selected areas.

Used oil filters from the Zortman light vehicles garage are crushed and sent to a sanitary landfill in Fergus County. "Floor dry" is an absorbent used to clean up spilled oils and lubricants in the light vehicle shop. Used "floor dry" is also sent to the county landfill for disposal. Used batteries are removed by a vendor for recycling. Broken glassware from the laboratories is triple rinsed with fresh water and sent to the county landfill for disposal. Filters and paper wastes from the labs are incinerated at the Zortman refinery. Empty cyanide containers are rinsed on a leach pad and the vast majority are returned to the vendor. A small percentage of empty cyanide drums are neutralized and either reused or crushed and sent to the County landfill for disposal. Zinc powder containers are rinsed and sent to the county landfill for disposal.

Solid Hazardous Wastes, including approximately 4 tons per year of cupels and slag generated from the assay lab, are barreled and shipped by truck to the ASARCO smelter in East Helena for disposal. Slag from the refinery and carbon fines from the Landusky processing plant are stored in containers on the Zortman 82 leach pad and are also sent to the ASARCO smelter for further refining and disposal.

Liquid Hazardous Wastes, such as assay and research lab solutions containing cyanide and acid, are collected in 55 gallon plastic barrels and disposed of on the Zortman 89 leach pad. MIBK, an organic compound used to aid in acid digestion, is collected and stored prior to shipping to an approved disposal site. Runoff solution from the fume scrubber on the assay lab is collected in drums and disposed on a leach pad. Non-salvageable materials that have had contact with cyanide solution have in the past been disposed by burial in active heaps, but all cyanide bins and a majority of empty cyanide barrels are now recycled back to the chemical supplier. ZMI is registered with the EPA and DHES as a Conditionally Exempt Small Quantity Generator of hazardous waste (ID# MTD089515495).

Other Wastes generated at the Zortman Mine include metal hydroxide sludge produced at the water treatment plant. This sludge is presently disposed of in a trench on the 89 leach pad. Approximately 2,000 tons of treatment plant sludge are generated and disposed of annually. Precipitate or sludge has settled on the bottom of various ponds at the Zortman Mine. At the time of closure and reclamation of these ponds, this sludge will be tested and may be disposed of on the waste rock repository directly, mixed with cement and disposed of on-site, or shipped to an approved disposal facility off-site, depending on the metals concentration and/or toxicity of the sludge and relevant regulatory requirements at that time.

3.14.3.3 Chemical Use, Storage, and Consumption-Landusky Mine

Unlike the Zortman Mine, which stopped producing ore in 1990, the Landusky Mine is currently producing and processing ore. As a result, chemical use at the Landusky Mine is considerably higher at present.

The following is a discussion of chemical use, storage, handling, and an estimate of the amount of each compound consumed specifically at the Landusky operation.

Gasoline is used to power the mine's light vehicles. It arrives on site by bulk truck in 500 to 2,000 gallon batches and is off-loaded into one 1,000 gallon tank on a concrete containment pad in the Landusky fuel farm area. The estimated annual usage of gasoline is 61,000 gallons at the Landusky Mine.

Diesel Fuel is used to power the mine trucks and vehicles. It arrives on site by tanker truck and is off-loaded into 4 - 10,000 gallon aboveground tanks, located in the contained fuel farm area near the vehicle maintenance shop. The diesel arrives at the mine site in 10,000 gallon lots. Estimated annual consumption is 2.6 million gallons per year. Smaller trucks and equipment are fueled at the fuel farm, while larger pieces of equipment are fueled by a tanker truck.

Oil and Lubricants are used for lubrication of mine equipment. Oil products include rock drill oil, lubricant oils, hydraulic fluids, engine oils, and transmission fluids. Oil is stored on the concrete fuel farm containment pad adjacent to the diesel fuel tanks in 3 - 8,000 gallon aboveground tanks in the contained fuel farm area and 1 - 3,000 gallon tank. Waste oil is stored in an 8,000 gallon tank prior to transport off-site. Shipment sizes

for these compounds vary. Annual usage for the Landusky Mine is approximately 80,000 gallons/year.

Antifreeze comprised of ethylene glycol is used as engine coolant for the mine fleet. It arrives in bulk trucks in 100 to 1,000 gallon batches and is off-loaded into a 1,500 gallon aboveground tank located adjacent to the diesel fuel and oil tanks in the contained fuel farm area. Used antifreeze is stored in a 1,500 gallon aboveground tank in the same area. Estimated annual usage at the Landusky Mine is 8,500 gallons. Waste antifreeze is transported to a temporary storage area on containment in the Landusky fuel farm. It is subsequently transported off-site for recycling.

Citrus-Based Solvent is non-hazardous and is used for parts washing. Estimated amount used at the Landusky Mine is 800 gallons per year. Solvent is stored in the vehicle maintenance shop. A private vendor periodically removes the spent solvent from the mine site and provides new solution.

Sodium Cyanide is used to dissolve the gold and silver in the leaching process. The dry sodium cyanide is stored on the 87 leach pad in the flo bins it was shipped in. Empty cyanide bins are washed and sent back to the distributor on the same truck that brings the product to the plant. Truck loads are approximately 20 tons. Estimated quantity of sodium cyanide used per year for the Landusky Mine is 1,750 tons.

Lime is used to control the pH during the metal extraction process and is also used for pH control at the water treatment plant. Lime is stored in 100 ton silos near the processing plant and ponds. The lime is fed from the silos onto the transfer conveyors at the leach pad site. Lime is shipped to the mine in a tanker trailer carrying about 20 tons. At present, approximately 18,000 tons per year are consumed at the Landusky Mine.

Ammonium Nitrate is the main ingredient in the blasting agent "ANFO." It arrives at the site in a pneumatic tanker trailer. It is off-loaded to three 100-ton silos located near the 1984 pad where it is stored until usage. Annual usage is approximately 4,000 tons. About 65 tons are maintained on site.

Anti-Scalants are used to prevent scaling around the pump intakes and in the spray and return line. Anti-scalants are shipped to the mine site by truck in small batches of about 1,000 to 2,000 gallons, and stored on the 87 leach pad adjacent to the processing plants in a 3,100 gallon aboveground tank and adjacent to the barren pond in a 2,000 gallon tank. Approximately 8,200 gallons of anti-scalant are used per year at the Landusky Mine. Empty anti-scalant bins are returned to the vendor.

Flocculent is used to settle small particles out of the solution which create problems in the clarifiers in the metal extraction process. Flocculent is shipped to the Landusky Mine in one-ton metal containers and is stored on the 87 leach pad. Approximately 150 gallons of Nalco 7852 flocculent are used annually at the Landusky Mine. Empty containers are returned to the vendor.

Powdered Zinc dust is used in the Merrill-Crowe plant at the Landusky Mine for extraction of gold. At present, approximately 110 tons per year are consumed in this process. Zinc is stored in 5 gallon buckets adjacent to the plant on the 87 leach pad. Used zinc barrels are rinsed with fresh water, crushed, and disposed of in a sanitary landfill in Fergus County, along with other non-hazardous solid waste.

Hydrogen Peroxide is used at the end of mine life to destroy cyanide in heap leach rinsate solution if natural degradation of cyanide needs to be accelerated. Hydrogen peroxide is shipped to the Zortman Mine in double-walled tanker trucks which unload into a double-walled aboveground storage tank on the Zortman 82 leach pad. An estimated 10,000 to 20,000 gallons of 70 percent hydrogen peroxide may be required, depending on amount of natural degradation of cyanide compounds. Approximately 550 gallons of H_2O_2 are kept on hand at the Landusky Mine.

Calcium Hypochlorite is used on a very infrequent basis to neutralize cyanide solution which may have leaked or spilled out of containment systems. This material is stored in the shipping containers on the 82 leach pad at the Zortman Mine and is transported and used at the Landusky Mine only when needed. Calcium hypochlorite is shipped to the Zortman Mine in 100 pound containers. Annual usage is at the Landusky Mine determined by the event and magnitude of spills requiring neutralization.

3.14.3.4 Waste Disposal-Landusky Mine

Solid Waste from the Landusky Mine is disposed in accordance with the rules and regulations of the Waste Management Division of Montana Department of Health and Environmental Sciences. As described for the Zortman Mine and mine office, municipal Class II solid waste is compacted at the mine and transported to

a sanitary landfill in Fergus County for disposal. Inert, Class III wastes such as wood and concrete are occasionally buried on site in selected areas.

Used oil filters and "floor dry" absorbant from the Landusky vehicle maintenance shop are disposed of at the county landfill. Used vehicle batteries are removed by a vendor for recycling. Empty cyanide bins are rinsed on the 87 leach pad and shipped back to the manufacturer. Empty zinc barrels are rinsed, crushed, and disposed of at a sanitary landfill in Fergus County.

Solid Hazardous Wastes in the form of carbon fines from the carbon absorption plant are transported and stored at the Zortman Mine. Carbon fines are then shipped offsite for further refining and disposal at an approved site.

Liquid Hazardous Wastes, such as the waste oil and used citrus-based solvent, generated at the Landusky vehicle maintenance shop are stored in tanks on the containment pad in the fuel farm area and then picked up by an EPA-licensed vendor for reprocessing. Since all laboratory analyses are performed at the ZMI laboratory in the town of Zortman, no laboratory wastes are generated at the Landusky Mine.

Other Wastes generated at the Landusky Mine include precipitate or sludge on the bottom of on-site ponds. Similarly, iron precipitate has settled on the bottom of the 85/86 contingency pond from stored drainage from the Gold Bug Adit. As described for the Zortman Mine, the ultimate disposal of these precipitates or sludges will depend on their chemical composition, their toxicological properties, and relevant regulatory requirements at the time of closure and reclamation.

3.14.4 Accidental Spills and Releases of Hazardous Materials - 1979 to Present

Since the commencement of mining by ZMI in 1979, there have been five known accidental spills or releases of cyanide into the environment. The following is a summary of those releases, including a description of the suspected amount of material released. A discussion of environmental impacts associated with these releases is presented in Section 4.14.

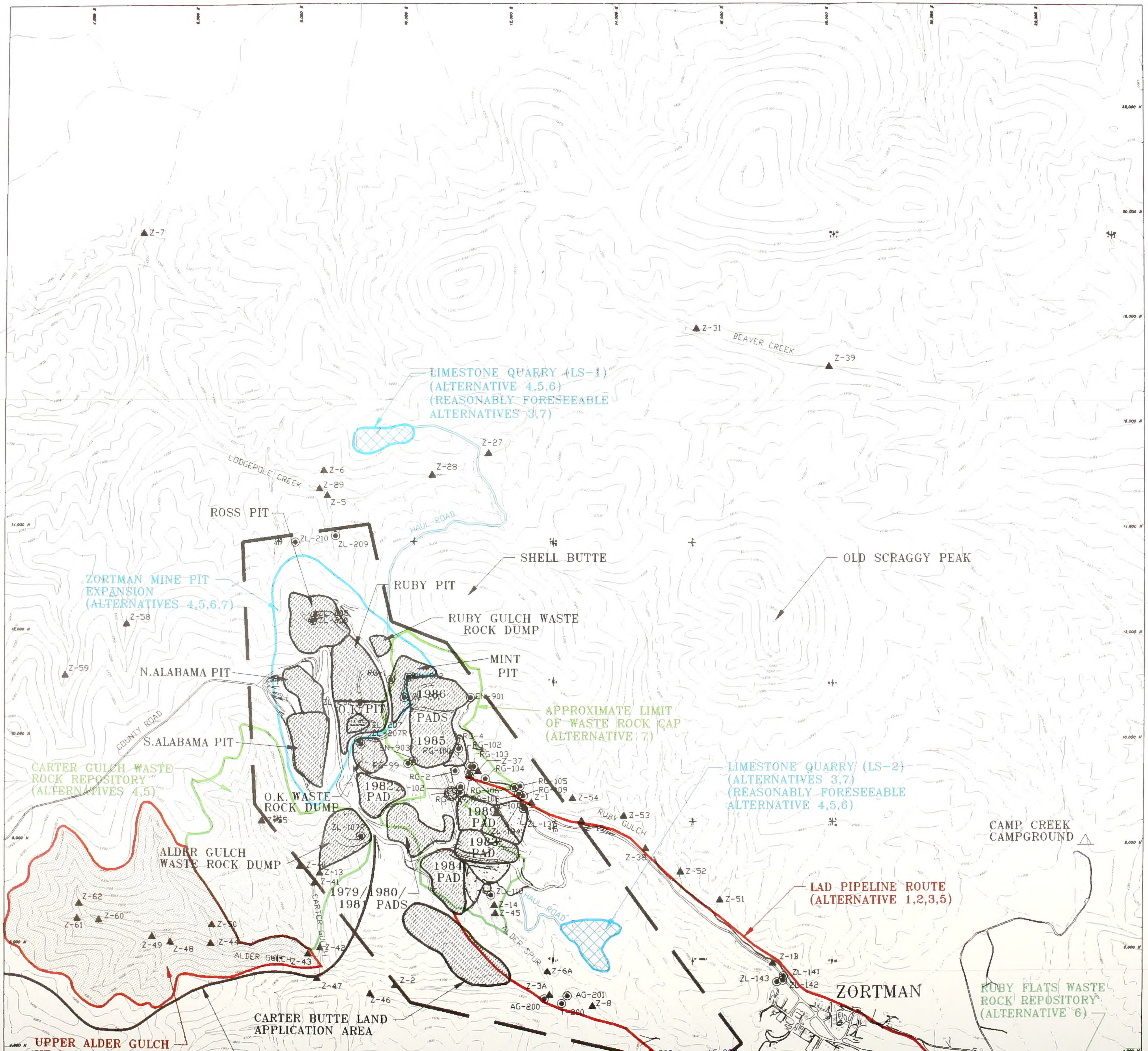
- On November 1, 1982, cyanide was detected in the Kalal groundwater supply system, located in Alder Gulch near the town of Zortman. The source of the cyanide was found to be a spray line on the Zortman 1982 leach pad that was accidentally drained off of the lined surface to prevent freezing. It is estimated that about four pounds of cyanide were spilled.
- On December 9, 1982, roughly 75 gallons of cyanide solution containing roughly 2 pounds of cyanide were spilled at the Landusky Mine. This solution was immediately neutralized.
- In June 1986, a leak of cyanide solution was detected in the rock drain below the Landusky 86 leach pad. The source of the leak was faulty installation of the leach pad liner. Low level cyanide concentrations were detected in surface water in Montana Gulch as far downstream as the Montana Gulch Campground. In response, ZMI increased the frequency of surface and groundwater monitoring in the area, installed a temporary pumpback impoundment, neutralized cyanide solution in downstream areas, and removed the ore and relined the leaking portion of the leach pad. After corrective measures were taken cyanide concentrations dropped considerably and the leak was considered successfully repaired.
- In October 1987, cyanide was detected in Ruby Gulch below the Zortman 85-86 leach pad. The source was identified as a leak in the pad liner. In response, the level of the solution in the leach pad was lowered below the level of liner failure. Although much of the leaked solution was neutralized in stream using hypochlorite, trace amounts of cyanide have been detected in upper Ruby Gulch.
- On July 7, 1992, cyanide was detected in monitoring well ZL-108 adjacent to the Landusky processing plant. In response, an inspection was carried out, groundwater monitoring at that location was increased, and a Notice of Noncompliance was issued.
- In September 1993, cyanide was detected in monitoring wells adjacent to a process pond at the Landusky Mine. The source of the leak was found to be improper seaming of the newly relined pond. A Notice of Noncompliance was issued. The pond was drained and relined. Pumpback efforts were initiated and additional wells were constructed. The amount of the leak is not known, but may have exceeded several thousand gallons. No offsite contamination of surface water or groundwater has been detected at monitoring sites.

In addition to the cyanide releases described above, one release of petroleum hydrocarbons, or diesel fuel, is known to have occurred at the Zortman Mine in September 1991. This release occurred from a leaking underground storage tank located near the Zortman truck shop. The leak was discovered when the tank was being removed from the site. The release was reported to the Montana Department of Health and Environmental Sciences (DHES). In response, all visually contaminated soil was removed by ZMI, along with an additional 200 yd^3. Soil sampling revealed that concentrations of petroleum hydrocarbons were below the relevant DHES action level. Based on consultation with DHES, the excavated soil was spread on the surface to allow the contamination to volatilize. According to DHES, no further investigation or clean up activities are needed for this release (DHES 1995).

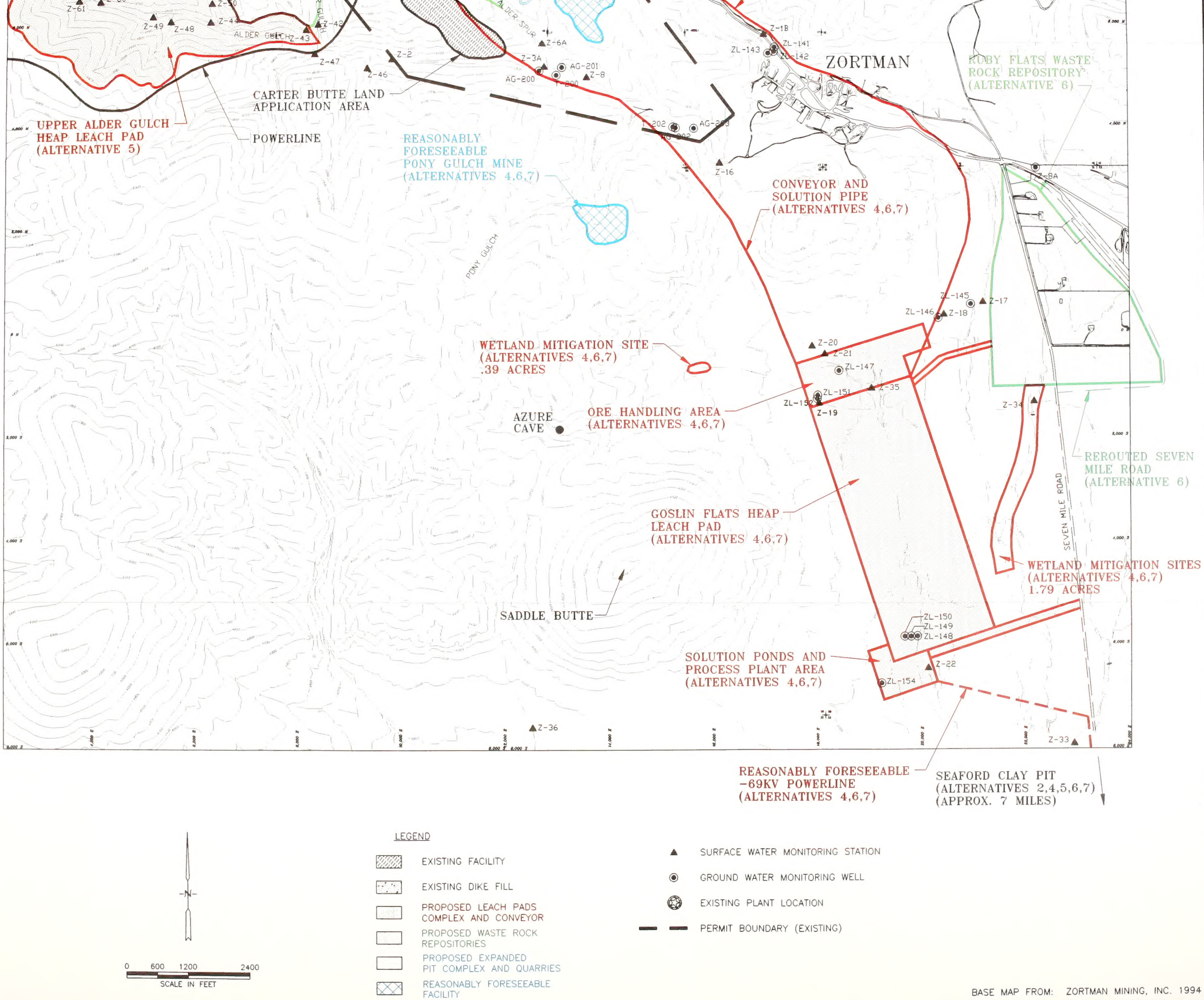
3.14.5 Emergency Response and Spill Contingency Planning

ZMI has developed two emergency response and spill contingency plans that mine employees have been trained to follow in the event of an accidental release of certain hazardous materials. The first of these plans is the "Cyanide Spill Contingency Plan", which was recently revised in 1995. In brief, this plan describes background information on the uses and applications of cyanide and chemical reactions that can occur with cyanide under different circumstances. More importantly, the plan describes personal safety, first aid, and medical treatment for individuals accidentally exposed to cyanide, as well as procedures for responding to accidental spills and transportation emergencies. The plan also describes cyanide unloading, handling, and storage procedures (Cyanide Spill Contingency Plan 1995).

The second emergency response plan that ZMI has prepared is the "Spill Prevention Control and Counter Measure Plan (SPCC) - Hydrocarbon Products". Specific objectives of the plan include: 1) reducing the potential for accidental spills and environmental contamination; 2) providing necessary information to operations staff to properly respond to a spill event; 3) defining responsibilities for spill notification and control of spills; and 4) providing a response and clean-up program which minimizes or eliminates environmental impacts (SPCC Plan 1995). The plan provides detailed information on hydrocarbon products used at the mines, storage areas, proper handling practices, inspection of tanks and storage facilities for leaks or spills, spill prevention, notification, and response training, and clean up or removal procedures for spilled fuel.



Z-7
Z-31
BEAVER CREEK
Z-39
LIMESTONE QUARRY (LS-1)
(ALTERNATIVE 4,5,6)
(REASONABLY FORESEEABLE
ALTERNATIVES 3,7)
Z-27
LODGEPOLE CREEK
Z-6
Z-28
Z-29
Z-5
ROSS PIT
ZL-210
ZL-209
HAUL ROAD
SHELL BUTTE
OLD SCRAGGY PEAK
ZORTMAN MINE PIT
EXPANSION
(ALTERNATIVES 4,5,6,7)
RUBY PIT
Z-58
RUBY GULCH WASTE
ROCK DUMP
Z-59
MINT
PIT
N.ALABAMA PIT
1986
PADS
O.K. PIT
APPROXIMATE LIMIT
OF WASTE ROCK CAP
(ALTERNATIVE 7)
COUNTY ROAD
1985
S.ALABAMA PIT
CARTER GULCH WASTE
ROCK REPOSITORY
(ALTERNATIVES 4,5)
LIMESTONE QUARRY (LS-2)
(ALTERNATIVES 3,7)
(REASONABLY FORESEEABLE
ALTERNATIVE 4,5,6)
1982
PAD
O.K. WASTE
ROCK DUMP
Z-54
1989
PAD
RUBY GULCH
Z-53
CAMP CREEK
CAMPGROUND
1983
PAD
ALDER GULCH
WASTE ROCK DUMP
1984
PAD
Z-38
Z-52
LAD PIPELINE ROUTE
(ALTERNATIVE 1,2,3,5)
1979/1980/
1981 PADS
Z-51
Z-62
Z-61
Z-60
Z-50
Z-49
Z-48
ALDER GULCH
Z-43
CARTER GULCH
Z-42
ALDER SPUR
Z-6A
Z-1B
ZL-141
ZL-143
ZL-142
Z-47
Z-2
Z-3A
AG-201
AG-200
Z-8
Z-46
ZORTMAN
RUBY FLATS WASTE
ROCK REPOSITORY
(ALTERNATIVE 6)
CARTER BUTTE LAND
APPLICATION AREA
UPPER ALDER GULCH

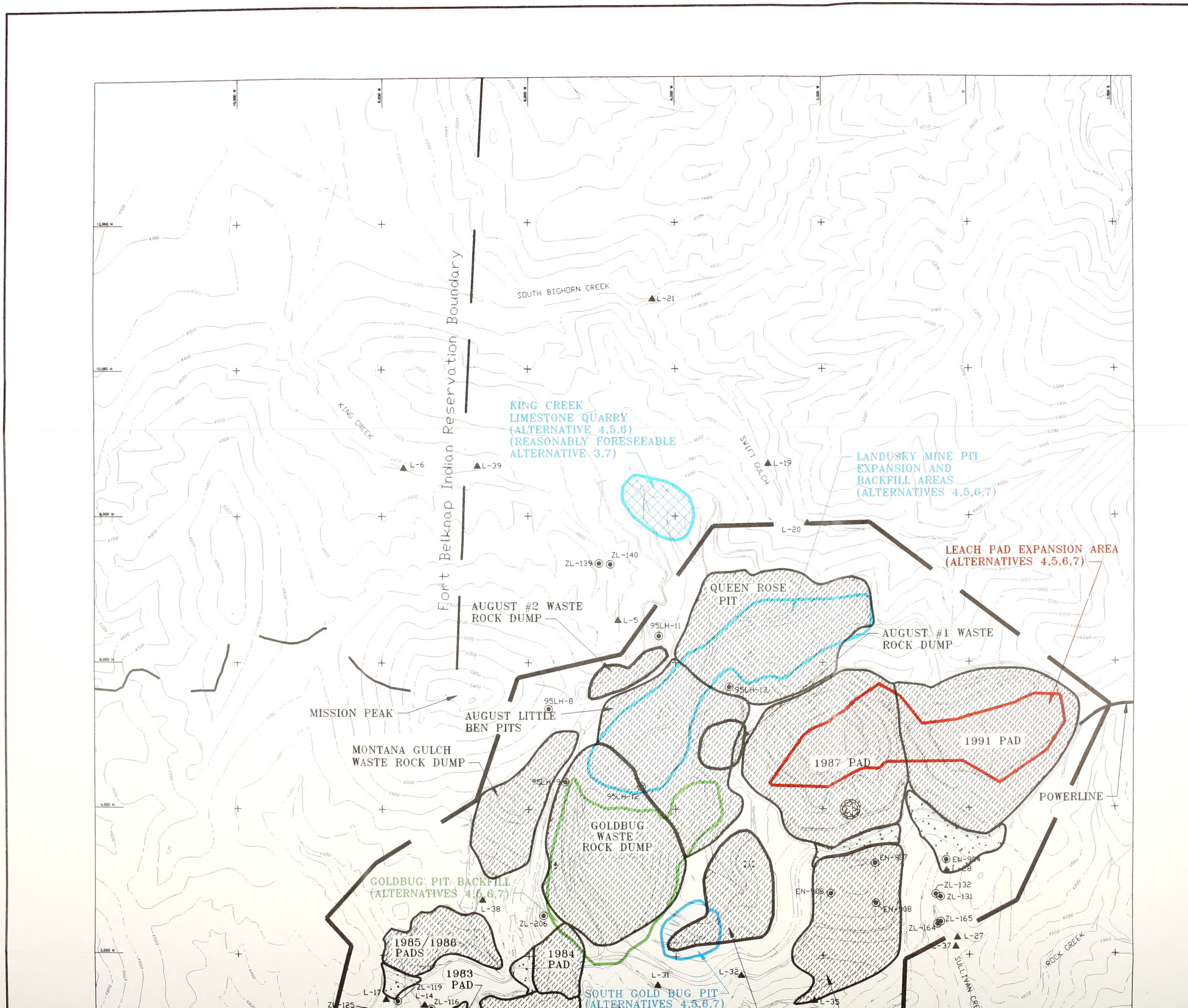


BASE MAP FROM: ZORTMAN MINING, INC. 1994

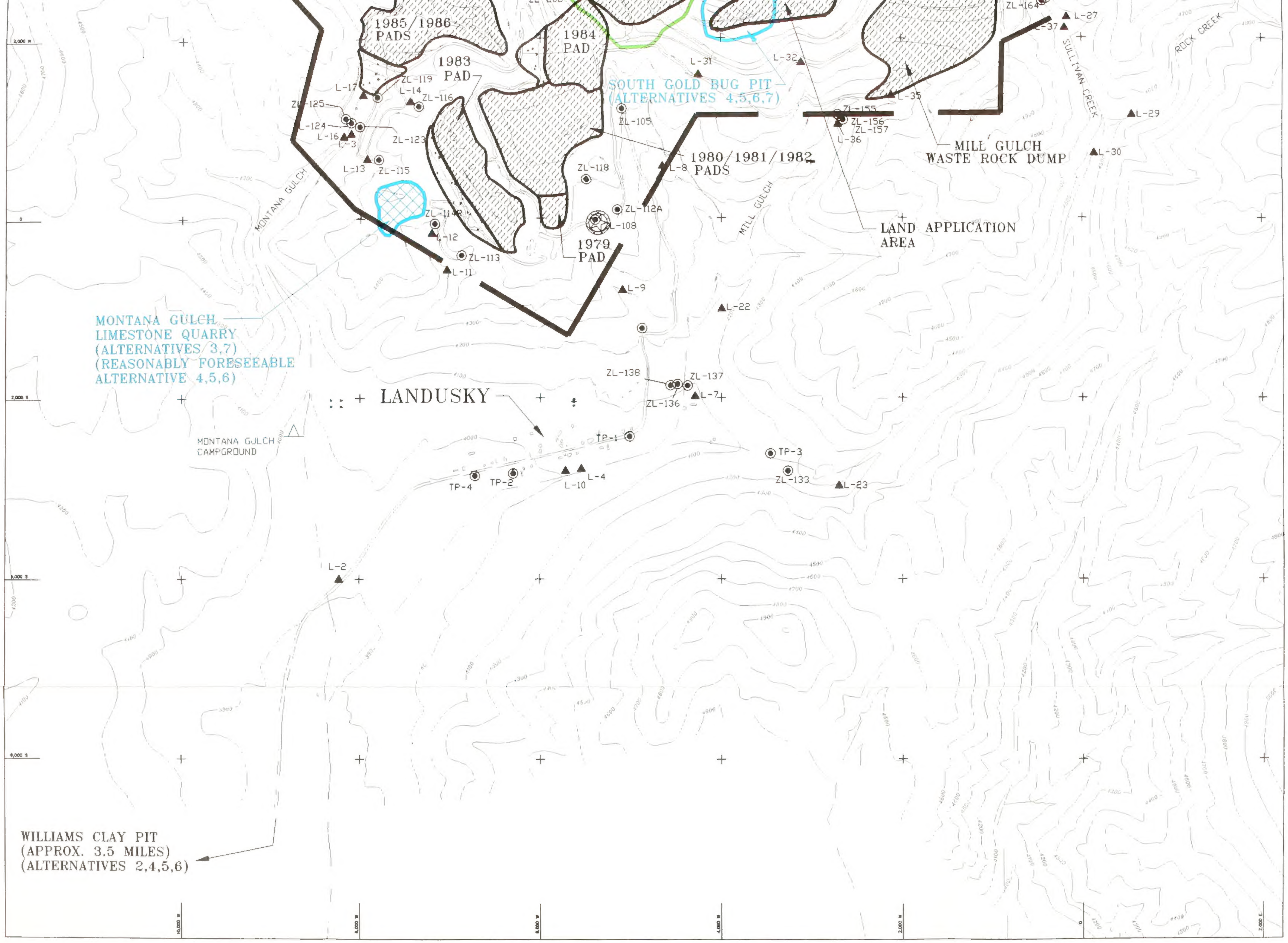
EXISTING AND ALTERNATIVE FACILITIES LOCATION WITH SURFACE WATER AND GROUNDWATER MONITORING LOCATIONS AT ZORTMAN MINE

EXHIBIT 1

ZOR-FAC



Fort Belknap Indian Reservation Boundary
SOUTH BIGHORN CREEK
KING CREEK
SWIFT GULCH
KING CREEK
LIMESTONE QUARRY
(ALTERNATIVE 4,5,6)
(REASONABLY FORESEEABLE
ALTERNATIVE 3,7)
LANDUSKY MINE PIT
EXPANSION AND
BACKFILL AREAS
(ALTERNATIVES 4,5,6,7)
LEACH PAD EXPANSION AREA
(ALTERNATIVES 4,5,6,7)
QUEEN ROSE
PIT
AUGUST #2 WASTE
ROCK DUMP
AUGUST #1 WASTE
ROCK DUMP
MISSION PEAK
AUGUST LITTLE
BEN PITS
MONTANA GULCH
WASTE ROCK DUMP
1991 PAD
1987 PAD
POWERLINE
GOLDBUG
WASTE
ROCK DUMP
GOLDBUG PIT BACKFILL
(ALTERNATIVES 4,5,6,7)
1985/1986
PADS
1984
PAD
1983
PAD
SOUTH GOLD BUG PIT
(ALTERNATIVES 4,5,6,7)
ROCK CREEK
L-21
L-6
L-39
L-19
L-20
ZL-139
ZL-140
L-5
95LH-11
95LH-13
95LH-8
95LH-12
L-38
ZL-206
L-31
L-32
L-35
L-17
ZL-119
L-14
ZL-116
EN-907
EN-904
ZL-132
ZL-131
EN-908
ZL-165
ZL-164
L-27
L-37



-N-

0 400 800 1600
SCALE IN FEET

LEGEND

EXISTING FACILITY

EXISTING DIKE FILL

PROPOSED LEACH PADS COMPLEX

PROPOSED WASTE ROCK REPOSITORIES

PROPOSED EXPANDED PIT COMPLEX AND QLARRIES

REASONABLY FORESEEABLE FACILITY

SURFACE WATER MONITORING STATION

GROUND WATER MONITORING WELL

EXISTING PLANT LOCATION

PERMIT BOUNDARY (EXISTING)

BASE MAP FROM: ZORTMAN MINING, INC. 1994

LAND-FAC

EXISTING AND ALTERNATIVE FACILITIES LOCATION WITH SURFACE WATER AND GROUNDWATER MONITORING LOCATIONS AT LANDUSKY MINE

EXHIBIT 2